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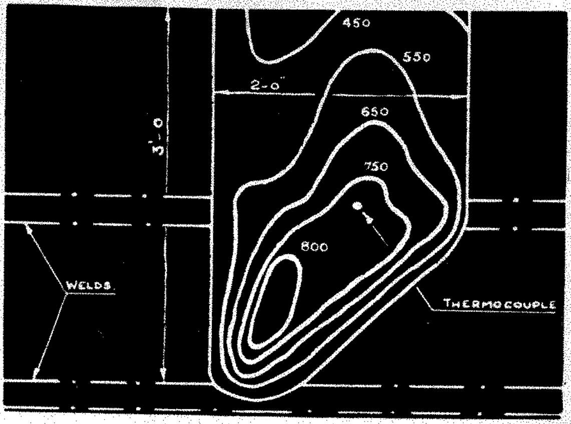

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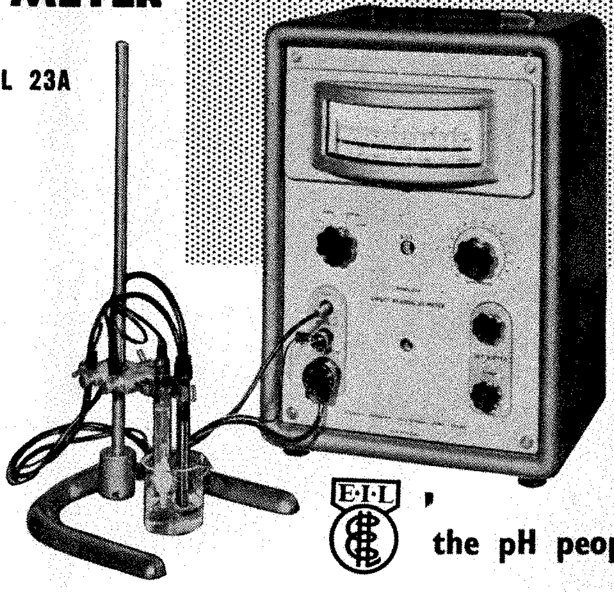

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SCIENCE AND TECHNOLOGY IN PUBLIC AFFAIRS

ALTHOUGH the seventh annual report of the National Science Foundation covers the year ended June 30, 1957 (see *Nature*, June 21, p. 1710), the expanded programmes for the Foundation announced by President Eisenhower in his message on education to Congress on January 27, 1958, gives especial interest to the report, apart altogether from the steps to improve and expand Anglo-American co-operation in research and development indicated by the President and Mr. Macmillan in their joint statement on their talks last October. In his budget message of January 13, President Eisenhower had proposed appropriations of 140 million dollars for the Foundation in 1959, compared with 40 million dollars in 1957 (apart from some 32 million dollars on account of the International Geophysical Year). Of this 40 million dollars, 664,561 dollars was allocated to national science policy studies, nearly 7,500,000 dollars to research grants in the biological and medical sciences, just over 7,500,000 dollars to research grants in the mathematical, physical and engineering sciences, and 289,100 dollars to the social sciences. Grants in support of research facilities totalled, in biological and medical sciences, 884,800 dollars, and in the mathematical, physical and engineering sciences, 4,496,899 dollars. Graduate fellowships received 3,353,605 dollars, education in the sciences 10,947,711 dollars, the President's Committee on Scientists and Engineers 117,517 dollars, the review of research and training 1,020,143 dollars, and the dissemination of scientific information 994,736 dollars, with 122,069 dollars for attendance at international scientific meetings.

It is expenditure of this order that is now to be increased to 58 million dollars on research grants and 82 million dollars (including 3 million dollars on administration) for the improvement and extension of education in science. The current annual report of the Foundation enables the British reader to judge more accurately the scale and character of the new efforts of the United States in this field, and to assess to some extent the new need for modifications and developments in our own effort, both to eliminate waste and inefficiency and to improve its balance and facilitate smooth co-operation with the United States. It is not so much the scale of the British effort in comparison with that of the United States that is in question as the character of the institutions by which it is operated, and the spirit and outlook in which they are administered; on this the present report of the National Science Foundation and the statement of its director, Dr. A. T. Waterman, in particular, throw a flood of light.

No one institution in Britain carries quite the responsibility and concern for scientific endeavour that the National Science Foundation bears in the United States. The closest approach is probably the office of the Lord President of the Council; but even so, responsibility is dispersed between him, the Advisory Council for Scientific Policy, the Defence Research Policy Committee, the University Grants Committee and various other bodies the concerns and efforts of which it could scarcely be said, as Dr. D. W. Bronk, chairman of the National Science Board, writes in this annual report, that they are "permeated by devotion to the belief that the furtherance of science enriches the intellectual and spiritual life of the people of our country, broadens and deepens the quality of our culture and ennobles our national ideals". Indeed, any consideration of incidents over the past few years suggests that the nearer we approach to ministerial level in Britain the less that is likely to be true. So far as the Government and its institutions are concerned, science is regarded as serving practical ends, rather than as a great adventure of the human mind.

That may be a primary reason why we lack an effective institution in Britain comparable to the National Science Foundation with its statutory responsibility "to develop and encourage the pursuit of a national policy for the promotion of basic research and education in the sciences". Much turns on the place which science and the scientist hold in the public esteem. One lesson which should have been impressed upon both the Government and the public by the shortage of technologists and of scientists, and especially of teachers of science and mathematics, is the dependence of the attractiveness of a career to the school-leaver or graduate on the esteem its practitioners enjoy in the public mind.

In this context, Dr. Waterman's exposition of his understanding of a national policy for science and its implications is of profound interest. Taking as science the accumulated knowledge concerning the world we live in and how it operates, which is steadily increased by active research, based on observation and experiment, Dr. Waterman emphasizes, first, that such exploration depends on an individual's choice of where and how to explore, and that the importance and flexibility of his project or programme and the significance of his final results can only be properly appraised and evaluated by his scientific colleagues in the same field. From that follows the fundamental importance of free communications and a national policy for fundamental research, at least; though no government or other agency can rationally attempt to formulate programmes for individual scientists, still less prescribe the methods of attack. Those must be left to the individual scientist: a national policy in science, at least as distinct from technology, must be limited to discovering the objectives which scientists regard as important and seeing that the scientists are provided with adequate means for the attack.

This implies, as Dr. Waterman indicates, whole-hearted support for competent basic research where needed; in particular, it implies provision of the capital facilities required in such fields as nuclear research, radio astronomy, and the scientific exploration of outer space, as well as proper attention to such auxiliary matters as the dissemination of research results, opportunity for conferences and travel to scientific meetings, and communications with other scientists at home and abroad. How far successive British post-war governments have been from such an approach can be demonstrated by referring to their treatment of recommendations of the Advisory Council for Scientific Policy regarding the National Lending and Reference Libraries for Science and Technology, the shelving of the whole project for a Science Centre, and the futilities which in the name of economy have recently interrupted work on the Isaac Newton Telescope and the appointment of an administrator with no scientific, technological or legal training to the comptrollership of the Patent Office. Even the admitted shortage of scientists and technologists has not brought the Government to appreciate what is wrong, or to take the steps that would avoid the present wastage of man-power and lead to greater efficiency, and real and not imaginary economies.

On the question of priorities of effort as between one science and another, Dr. Waterman observes that no field of science should be excluded from encouragement and support. We simply do not know where the next capital discoveries may occur. The only distinctions that can be made as to relative values are in terms of contributions to understanding of our world, generality of findings, techniques available, current rates of progress, available skilled man-power, and occasionally neglected or over-emphasized special areas when so identified by the scientists themselves. The question of what way science can best serve the nation and all mankind is completely different, and involves an appraisal of national and human needs and the matching to them of progress in the several fields of science. It is almost exclusively a practical matter, concerning the applications that can be made from scientific discoveries and principles; and it may be remarked in passing that a main theme of the report of Prof. C. F. Carter and Prof. B. R. Williams on "Industry and Technical Progress" was that in certain sectors of British industry much more needs to be done to extend the application of existing knowledge.

National needs, Dr. Waterman points out, can be described in terms of broad essentials such as food, health, defence, transport, housing, communication, power and water, and in these the policy of the Federal Government of the United States is at present to place on its own agencies the responsibility for technology related to its own mission. Each agency, however, is also encouraged to conduct and support basic research in fields of science related to its work. Besides this work in its own laboratories, the Federal Government supports basic research in universities, research institutes and laboratories throughout the country, and the National Science Foundation was established in 1950 to further the support of basic research comprehensively and actively on all fronts.

The Foundation attempts to do this in various ways and by a wide range of institutions, seeking the diversity and flexibility that are essential to secure the conditions in which scientific effort is most vigorous and fruitful. By keeping the different agencies informed of each other's interests, the proposals received and any action taken, the Federal Government is enabled to follow the lead of the scientists in determining the research to be supported, giving a truly national policy for the encouragement of science. That policy does not indeed provide unrestricted research funds for institutions or their departments, and although support by scientific project is criticized in some academic circles, the balance of scientific opinion regards it as satisfactory, though Dr. Waterman suggests the question should remain open. There are some exceptions, such as agriculture, where the policy is more in line with that adopted for industrial research associations in Great Britain, and, more recently, in the assistance given to some institutions for medical research. Dr. Waterman stresses the traditional policy of avoiding Federal aid to education, which in an important field has now been substantially modified in the President's message on education, as Dr. Waterman indeed forecast in his own statement. There are other questions, too, which he suggests need attention: the direction and the degree in which the Federal Government should extend its support for science, including the increase of research activity in its own laboratories; the advisability of establishing federally operated general research laboratories; and the way in which any necessary further support for training in science should be given.

Dr. Waterman stresses the over-riding urgency of prompt, effective and permanent measures in these matters; but no less clearly he points to the utmost importance of new measures or modification of existing measures and policy having the understanding and support of the people. Effective measures to strengthen education in science and technology and to increase the national research effort cannot be taken in a democracy without the full support of its citizens. While one outcome of an expansion of technical and technological education and of the development of a broad general education should be increased public understanding of its value and importance, we have to seek to promote that understanding simultaneously in order to secure the support and continuity which will permit those developments. The impact of society on science can be as important as the impact of science on society.

This latest annual report of the National Science Foundation does indeed emphasize the neglected truth to which Prof. E. W. R. Steacie directed attention in his Purvis Memorial Lecture last November, namely, that society ultimately controls technological innovation, and the vital question is whether the organization of government in Britain to-day is appropriate for the exercise of such control. Without, in fact, some understanding of science or particular technologies on the part of the administrator or statesman, it is improbable that he will appreciate the opportunities which potential technological developments offer, still less that he will face the awkward questions and difficult decisions that may be involved, and embark on the task of public education which is essential if support is to be forthcoming for the necessary decisions and policy.

In this influence that society exercises on the direction of technological advance lies the great danger of party politics, particularly under the influence of mass media of communication. As Prof. Steacie remarks, science has the major influence on what is possible, but only a minor influence on what is in fact done. An increasing proportion of the work of the National Science Foundation appears to be directed towards increasing the influence of science; and the development of Anglo-American co-operation in research and development, in the field of defence and elsewhere, depends ultimately on the extent to which, not only in the United States but also in Britain and in her partners in the North Atlantic Treaty Organization, the influence of science and technology on practical affairs and policy can be extended. We have to promote the will to use science and technology aright; and it is frightening that when the elements of control over our environment are within our grasp, we do not choose to use them.

Prof. Steacie's lecture does more than direct attention to some of the implications for the structure of government to-day. He sets science in the right context in relation to the technology of defence and to the question of education for this technological age. He rejects the idea that all scientists should be classed as second-rate citizens, and he pleads for a sane attitude towards specialization and discounts the pursuit of the argument of science versus the humanities. Somehow we must give the future leaders of society a general idea of the aims and methods of science, the lack of which is often a dangerous factor in our situation. He condemns the tendency, illustrated, for example, over the launching of artificial Earth satellites, to treat scientific advance as a race, with emphasis on nationalism, and, no less forthrightly, the consequent major importance attached to the keeping of secrets, with grossly exaggerated security measures.

The Purvis Memorial Lecture and the National Science Foundation's report both demonstrate how much common thought there is in Canada, in Britain and in the United States. While, however, each country may have much to learn from the other, the essential conditions of scientific and technical advance are independent of national boundaries; the establishment of those conditions and the administrative structure required to create and nurture them are problems for each national administration, and indeed for all those citizens, whether scientists or technologists or not, who are concerned with their country's economic and industrial future, its social welfare or its security. Both Prof. Steacie and Dr. Waterman, however, in challenging further thought as to the adequacy of Britain's present institutions, seem to point to the opportunity which a body such as the Parliamentary and Scientific Committee has of playing an increasing part in directing attention to problems and stimulating fresh thought about methods and needs.

There is welcome evidence that this is being done. The Committee has already taken action regarding the recent appointment of the comptroller-general of the Patent Office and on the payment of rates by scientific societies. The discontinuance of the Isaac Newton telescope and the question of scientific libraries are matters that fall well within its scope of action within recent years, particularly in relation to scientific and industrial research. The Committee this year heard authoritative addresses on space satellites and relevant matters, and on the use of thermonuclear energy at power stations. Such addresses might well suggest a re-assessment of national power policy in terms of the increase in capacity of the nuclear power station in relation to capital cost. The implications of these developments for both the man-power and capital invested in research and development require consideration from a wide national point of view, and especially with reference to the resources in capital and man-power already collected in industrial groups.

It is not suggested that the Parliamentary and Scientific Committee could do all that is required; but if it enjoyed strong support from scientific and professional institutions, with that of members of Parliament alive to the issues involved, it should be able to insist on public discussion at a level high enough to be embarrassing to any Government which sought to ignore the facts. With that, however, must go a continuing task of public education to create understanding which will support the policies required. Of the opportunities and responsibilities which confront the individual scientist and technologist, as a professional man and a citizen, the Purvis Memorial Lecture and the National Science Foundation report, like the recent annual report of the Parliamentary and Scientific Committee, give clear indications.

TECHNOLOGY: 1500–1750

A History of Technology

Edited by Charles Singer, E. J. Holmyard, A. R. Hall, and Trevor I. Williams. Vol. 3: From the Renaissance to the Industrial Revolution *c.* 1500–*c.* 1750. Pp. xxxvii+766+32 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 168*s.* net.

THE third volume of this monumental work, produced under the same editors with the continued assistance of Imperial Chemical Industries, Ltd., carries the story from the Renaissance to the dawn of the Industrial Revolution, and maintains the high standard of the earlier volumes already commended in *Nature* (176, 182; 1955: and 179, 709; 1957).

As before, the matter is not strictly confined to the dates given, and indeed the treatment of cartography, the calendar, town planning, and precision instruments extends back two thousand years or more.

The most important event of the period was the invention of printing in the second half of the fifteenth century, which is admirably described in a chapter by Michael Clapham. The resulting flood of printed books accelerated technological progress by bringing about the rapid diffusion of knowledge. It also led to the attempt to re-discover ancient techniques and thus led to new knowledge. An additional consequence is that historians are able to draw on the new technical literature, and the wealth of material available in such writers as Biringuccio and Agricola and in the "Books of Trades" culminating in the great French "Encyclopaedia" both reduces the relative importance of archæological evidence and faces the editors and authors with difficult tasks of selection.

Corresponding with the expansion of the general knowledge of the educated man occurred the expansion of the Western world with the voyages of exploration made possible by the development of the full-rigged ship described in the chapter by G. P. B. Naish. This raised problems of navigation which could only be solved by the successful application of science. It was in the field of navigation, surveying, and time measurement that scientific solutions were first required, and the art of instrument-making which arose was later of great service to science itself in making possible the provision of optical instruments and other physical apparatus such as thermometers, vacuum pumps, and electrostatic machines. These topics are extensively treated in two chapters on cartography, survey and navigation by Charles Singer, D. J. Price, and E. G. R. Taylor; in two chapters on precision instruments by D. J. Price; and by H. Alan Lloyd on mechanical timekeepers.

The increased consumption of wood for shipbuilding and also in the extraction of metals led to the increased use of coal and made the problem of mine drainage more urgent, with the ultimate consequence of giving rise to Newcomen's invention of the steam engine. Although its advent thus falls within the period of this volume the steam engine is not discussed, since its main impact on society came later. Coal mining is treated by J. U. Nef, and Cyril Stanley Smith and R. J. Forbes write on metallurgy and assaying. Pumps are described by A. P. Usher in his chapter on machines and mechanisms.

In the period under review the northern European countries with their access to the ocean and their abundant sources of coal and metalliferous ores came to the fore and thus the centre of technological advance was displaced from the Mediterranean region where it had been since antiquity. North-west Europe was the region where the majority of the land drainage and reclamation works, described by L. E. Harris, and the canal construction, described by A. W. Skempton, were carried out.

The scientific approach was of value in the chemical industry as is shown by F. W. Gibbs, but it did not by any means always succeed in transforming craft methods. Thus dynamics was of no assistance in gunnery without the requisite precision-made equipment to profit from it, though much experimentation to improve gun construction took place, as is described by A. R. Hall in his chapter on military technology.

R. Patterson continues his account of the textile industry in which attempts to achieve mechanization fell short of success except in the ribbon loom and the knitting machine. The chapter on figured fabrics by the late J. F. Flanagan seems to be somewhat outside the scope of the book since the subject is more a matter of art than of technology. The same may be said of town planning by Martin S. Briggs, who has also contributed a chapter on building construction. A branch of the latter subject is given detailed treatment by S. B. Hamilton in his chapter on bridges.

R. A. Salaman writes of tradesmen's tools and their specialization and, with J. Geraint Jenkins, gives a detailed account of the trades of the wheelwright and the cooper. The latter author, with Olga Beaumont, contributes a chapter on farm tools, vehicles, and harness. Other contributions are on food and drink by R. J. Forbes, windmills by Rex Wailes, glass by R. J. Charleston and L. M. Angus-Butterworth, and the calendar by Sir Harold Spencer Jones.

The volume is well provided with text figures, many of which are, as before, drawn by D. E. Woodall.

K. R. GILBERT

NUCLEAR ENGINEERING

Selected Papers from the 1st Nuclear Engineering and Science Congress

Held at Cleveland, Ohio. Edited by D. J. Hughes, Stuart McLain and Clark Williams. Vol. 1: Problems in Nuclear Engineering. Pp. vi+365. Vol. 2: Reactor Operational Problems. Pp. ix+278. (London and New York: Pergamon Press, 1957.) £6 each volume or £10 the set.

THESE two volumes contain a selection of the papers presented at the first Nuclear Engineering and Science Congress held at Cleveland, Ohio, during December 12–16, 1955. This Congress was organized by the Engineers' Joint Council in order to present to American engineers and scientists information made available earlier at the International Congress on the Peaceful Uses of Atomic Energy at Geneva and additional information on engineering subjects. The delay between presentation and publication of papers in such a rapidly growing subject is regrettable.

Binding and printing are good apart from a few typographical slips. Some of the illustrations are unsuitable for reproduction but this is presumably the fault of the authors rather than the editors.

Each of the two volumes is divided into four sections, Volume 1 being devoted to site selection, materials, design and heat transfer, while Volume 2 covers waste disposal and radiation hazards, chemical processing, reactor physics and control and instrumentation. Almost all the authors of the eighty-eight papers are from the United States but there are one or two papers from the United Kingdom and Canada. The title of the first volume, "Problems in Nuclear Engineering", appears to be reasonably representative of the contents but that of the second, "Reactor Operational Problems", is ill-chosen since only about one-eighth of the book is devoted to reactor operation, the remainder being mostly concerned with chemical problems.

As is to be expected in a collection of conference papers, each of which must stand alone, there is much repetition of introductory and background material. For example, at least half the papers devoted to site selection, safety and economics in Volume 1 tell us that humans must be protected from the radiations emitted by nuclear reactors. One paper uses well over two hundred words to prove arithmetically that no generalization can be made about the number of people who might be involved in a reactor incident. This could be more easily tolerated if the arithmetic were correct. Perhaps the most interesting paper in this section gives an account of a logical method of site selection by Topping, although one is struck by the apparent absence of objections by bodies concerned with the preservation of amenities.

The nineteen papers on materials form a reasonable discussion of the problems involved in selecting, making and fabricating suitable reactor materials. Some of these papers have a wealth of data in them although there are also some surprising omissions. For example, a paper by Johnson on ceramic fuel for nuclear reactors includes a table describing the change in thermal conductivity of a wide range of ceramic materials after irradiation by neutrons, but all information about uranium and thorium ceramics is omitted. The paper by Huddle on the oxidation behaviour of reactor materials is the most readable in the whole of Volume 1 and is the only paper which is an outcome of work on gas-cooled reactors.

Of the eleven papers included in the section on design, two are merely reviews of nuclear engineering and technology literature. The remaining nine include one by Kasschou describing generally the U.S. Army Package Power Reactor, while the other papers confine themselves to particular aspects of reactor design ; but there is none directly relating to gas-cooled reactors.

The heat transfer section of Volume 1 is short, having only five papers, but two of these, one by Carbon, Gilbert, McNutt and Neider on steam generation in a reactor and the other by Miller, Byrnes and Benforado on heat transfer to water flowing parallel to a rod bundle, contain many useful experimental results. A paper by Alexander describes how the amount of heat produced in the fuel, cans, moderator and other reactor materials may be estimated. It is unusual to find this subject discussed in such detail at a conference and it is a great pity that the author did not include a worked example for illustration.

The first section of Volume 2 contains eleven papers under the heading of waste disposal and radiation hazards, among which those by Hatch and Regan and by Warde and McVay deal with the disposal of radioactive wastes by fixation on baked clay or sintered aluminium oxide. In spite of these and other discussions of sophisticated methods of disposal, the storage of solutions in tanks appears to be the only method in large-scale use, and Wilson discusses its economics. Monitoring and decontamination of water are discussed by Setter and Goldin and by Morton and Straub, respectively, and Eisenbud describes the stations of the monitoring network for fall-out in the United States.

In the second section there are papers on aqueous and organic liquid processing of spent fuel. There are also discussions of dry systems using the distillation of volatile fluorides, by Hyman, Sheft and Katz, by Page, Raseman, Scarlett and Goodman, and by others. Dwyer writes on fused-salt extraction of uranium-bismuth liquid fuel, and pyrometallurgical processing is discussed by the Argonne Laboratory staff. The engineering design of an aqueous plant which can be decontaminated to permit direct maintenance is described by Kennedy and Reid.

The third section contains nine papers devoted to experimental and critical assemblies and reactor physics. The use of a travelling ion chamber connected to a recorder to obtain the exponential flux distribution in a heavy-water system is described by Towler and Wade. Another paper describes an exponential facility in which small samples of particular lattice systems can be tested in a cavity enclosed by a standard lattice array. Two papers mention work on the EBR1. Kato, Kirn and Redman measured conversion ratios by activating foils of uranium-235 and uranium-238, and Crouthamel and Turk estimated fission and conversion rates by chemical analysis of suitable fission and neutron capture products.

The final section contains two papers on instrument developments by Pearson and by Bryant, Carlson, Curtis and Kaufmann, and one on reactor instrumentation experience at Chalk River by Siddall. It also includes a paper on design experience of pressurized water-cooled reactors at Westinghouse by Hamilton, Grace, Meyer and Wilson. Theoretical papers on the reactivity value of multiple control rods and on power reactor control are contributed by Murray and by Van Rennes, Simons and Gray respectively.

B. CUTTS
G. R. H. GEOGHEGAN

SOME ASPECTS OF BIOPHYSICAL CHEMISTRY

Biophysical Chemistry

By John T. Edsall and Jeffries Wyman. Vol. 1: Thermodynamics, Electrostatics, and the Biological Significance of the Properties of Matter. Pp. xv+700. (New York: Academic Press, Inc., 1958.) 14 dollars.

IT is unfair to the cooks to give a final judgment on a meal half-way through, and for this reason impressions of the present volume may be modified when the second volume appears. The book is based on a course of lectures on the physical chemistry of biochemical systems which the authors have given at Harvard, and is clearly intended for students who are going to be concerned with studies of biological materials. It assumes little or no prior knowledge of physical chemistry—in any event, it deals with thermodynamics from first principles and has chapters on electrical conduction of aqueous solutions, and on acid-base equilibra, all of which are normally taught as simple physical chemistry. On the other hand, there is nothing about the kinetics of simple reactions, although the rate of dehydration of carbonic acid is discussed.

It seems to me that the aims of the authors are rather confused. Certainly in Great Britain it would be better to assume that all students who are going to concern themselves with the physical chemistry of proteins will have had an elementary course in physical chemistry, which would normally include elementary thermodynamics and its application to aqueous solutions as well as the basic studies of kinetics. If these were omitted, the present volume would not only be much shorter (and cheaper) but, by concentrating on biological applications of physical chemistry, it would avoid repeating the ground covered in numerous other works.

One can understand the difficulty of deciding where to begin but, surely, in starting with first principles, the authors have gone too far. They are postulating the existence of students who have decided to study 'biophysical chemistry' at the very start of their physical chemical education. I find it difficult to believe that this *avis mirabilis* exists.

If one can judge the contents of the whole work from this volume, together with the announced tentative contents of Volume 2, it might be fair to suggest that the title should be "Chapters in Biophysical Chemistry". Although some subjects (those in which the authors are particularly interested) are discussed in detail, others are scarcely mentioned. Enzyme processes are only briefly mentioned under the binding of molecules to proteins. Diffusion is not included in the elementary theory, suggesting that the authors think that diffusion processes are of no importance in biological systems. Under polybasic acids one might have expected at least some account of the titration of nucleic acids, and although hydrogen bonds get fourteen entries in the index, there is no mention of hydrogen bonding in deoxyribonucleic acid.

Nevertheless, many libraries will be glad to have this volume on their shelves for the accounts of specialized topics such as the dissociation and dielectric properties of amino-acids, peptides and proteins, and for the excellent account of protein – ion interactions. J. A. V. BUTLER

HOMAGE TO THE HERRING

The Herring and its Fishery

By Dr. W. C. Hodgson. Pp. xiv+197+9 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 25*s*. net.

STATES have arisen and fallen, fortunes been made and lost, scientific reputations built up and humbled, through this lowly fish. Beauty is framed in pearls from its scales, art created from its dead body, heroism fashioned in the men who catch it.

It is fitting that the herring should have honour done to it; and in this book Dr. Hodgson—than whom there is no one better qualified—does just this in full and honest measure, and in a refreshing manner.

When M. Graham's "Sea Fisheries" (London, Arnold, 1956) appeared marine biologists were quick to note that the herring—although it had been so intensively studied—had no special chapter. It was perhaps natural then to hope that Dr. Hodgson would make good this deficiency, and that his treatment would make it an acceptable companion for that of his former director and colleague of long standing. This it is not. It has no bibliography, few references, and gives little help to the reader who wants to inquire further. But it remains a good book.

Two statements have recently come from the Lowestoft Fisheries Laboratory: one is in this book (p. 73), and is "Life to-day is ruled by science"; the other, on the dust-wrapper of "On the Dynamics of Exploited Fish Populations" (R. J. H. Beverton and S. J. Holt. H.M. Stationery Office, 1957), is "Science is prediction". These two statements and the logical consequences which flow from them are no more true to-day than they have ever been; but they seem to have determined much of Dr. Hodgson's attitude to his subject, and shaped the course of his researches.

He paints a clear picture of his methods of age determination, of the assessment, composition, and recruitment of stocks, of the possible origins and migrations of the shoals providing the major fisheries, and leads up by closely argued reasons to the basis of his predictions, ending in an admission of failure. It is hard to see how all this could be written without even a mention of Ford, Storrow, Farran, Holt, Cushing, Burd, and many others who have studied these problems so extensively.

In conclusion, he decides (p. 177) that only in "natural causes and fishing" is the responsibility for the "collapse of the East Anglian fishery" to be sought. He rejects the first, and accepts that it is the growing exploitation of the immature fish on the "Dogger nursery" for conversion to meal for animal feeding which is the principal agency in this collapse. Many agree with him; but others, who also accept that fishing activity is the responsible agent for the decline, have different views. There is, moreover, the insidious menace of pollution, the danger of which to sea fisheries in contained areas such as the North Sea remains almost wholly unsuspected even in the most enlightened quarters, and which he apparently has not considered. H. O. BULL

A MELANESIAN URBAN COMMUNITY

The Great Village

The Economic and Social Welfare of Hanuabada, an Urban Community in Papua. By Prof. Cyril S. Belshaw. Pp. xviii+302+8 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 30*s*. net.

IN immediate contact with Europeans in Port Moresby, capital town of Papua—which is administered by Australia—there lives a community of indigenous Papuans. This interesting account describes something of the social and economic life of these Melanesians, and discusses certain administrar tive problems that have arisen as a result of thei- living in an introduced environment. Their own culture has been severely affected by Western custom, and it has not always been possible for the Administration to find an acceptable substitute for the loss of a traditional practice. For example, living accommodation for the people of Hanuabada, "the Great Village", became an acute issue after the Second World War when the village, having been evacuated, was re-established. Thatched houses are not, however, satisfactorily replaced by buildings with an unceiled, corrugated iron roof and wooden walls (but has any Pacific administration found the solution to the modern housing problem ?).

The picture presented of this community to-day is a complex one. The villagers are Christians; yet they continue to practise sorcery and to worship the spirits of their ancestors. They have retained an urgent sense of the importance of ceremonial, as practised in the exchange of goods and in feasting; but whereas craft products like arm-shells constituted an essential element in exchange, these are now in part—though only in part—replaced by cash; and the monetary substitute has come to be accepted. Cash is now habitually used also for purchasing some of the articles required for presentation on social occasions, such as weddings and deaths; and cash itself is similarly used as a gift. This demand for cash urges those in need of it for these purposes to go out and work for monetary reward. But the point to note is that cash has only partially replaced the ceremonial products customarily used. Again, the traditional dancing ceremonies—frowned on by mission supporters as being against the Christian moral code—are performed less frequently now than hitherto, and contemporaneously there has been a decline in agricultural production; the nexus here being that feasting was and is an essential accompaniment of the dance series held in honour of some person or to celebrate some local occasion. Clearly additional food must be forthcoming for such events. It could not be bought with cash in earlier times : it had to be produced, and this encouraged and increased agricultural activity. But with the decrease in dancing has come a decrease in agricultural production. At the same time the villagers' assessment of the value of cash appears to be immature. They are prone to spend it on social requirements, such as ceremonial payments, to the detriment of their nutritional needs ; and the Administration's effort to improve their health conditions has met with a resistance backed by generations of conservatism towards change.

These few specimens from the descriptions in the survey can be summarized in a sentence : where the people have assimilated an element of Western culture they have not assimilated also its associated characteristics and institutions (F. C. Bartlett, "Psychology and Primitive Culture," Cambridge, 1923). This accounts to some extent for their present pattern of culture being made up of indigenous and European elements side by side. Where this close association of cultures exists it is to be expected that the entity of the less dominant one will suffer. That has happened in Hanuabada, and its people are not now enjoying the best of either.

But there are some signs of a brighter future. They seem to realize that a complete acceptance of Western custom is beyond competition. This may be a good feature in their mental attitude if it does not altogether stifle their ambition. They have shown themselves competent to administer co-operative societies on modern lines ; and administrative ability—and integrity—should stand them in good stead for any job requiring responsibility. Despite their comparatively low income they do, in fact, save money for specific purposes, even though the original incentive to save may be conveniently overlooked if an unexpected call for money arises for some quite different purpose. On the moral side, the people appear to have been attracted by the Scout movement and this, apart from its other intrinsic merits, has contributed towards good race relations with Europeans.

From an anthropological point of view the amount of detail that Prof. Belshaw has given is not consistent with its importance under the various headings of his subject. More could profitably have been included on women's customs (pp. 162 *ff.*)—very rightly collected by his wife—since absence of such knowledge hampers any administration in its ability to guide their advancement compared with the guidance for menfolk, of whose customs a far greater knowledge is available ; and the women's position in a society at any given time is often a criterion of its development towards an enhanced level of living. Another criterion of welfare in its widest sense is the rate of infant mortality over a period. The figure is high for the year when the survey was done, but it would have been helpful to know the trend of the infant mortality-rate. It is a pity that more material for the survey was not obtained in the vernacular and that so much reliance was—apparently—placed on the opinions of the three Papuan officials "without whose services the research could not have been completed in its present form" (p. ix). Comment by Hanuabadans on their own welfare as they see it now and in the future would have added to the value of the survey. If Prof. Belshaw had had longer experience in the British Colonial Service he would probably have appreciated the substantial difficulties of the Administration in Papua in its endeavours to improve the lot of the Hanuabadans. His advice to the Administration and criticism of its decisions might have been more appropriately confined wholly to a final chapter instead of being scattered throughout the book. The sixteen photographs could have been clearer and more illustrative of the text.

"The Great Village" is the first account of its kind to deal with this part of the Pacific. Coming from a trained anthropologist, the Administration will no doubt welcome it as a painstaking and independent survey of modern conditions, and it is a book that should well repay close study by all whose interests take them to work in Papua, particularly those with administrative interests. It has the added advantage of being a factual, first-hand record of the 'welfare anthropology' of the Hanuabadans at a time when they are constantly subject to changes imposed from outside.

G. K. Roth

GALILEO AND THE HOLY OFFICE

The Crime of Galileo

By Prof. Giorgio de Santillana. Pp. xvi + 339 + 8 plates. (London: William Heinemann, Ltd., 1958.) 30*s*. net.

THE literature on the process of the Holy Office against Galileo is enriched in this book with a most noteworthy contribution. Prof. G. de Santillana, a scholar who has earned an international reputation by his books and articles on the history of science, has reconsidered the whole much-debated issue, making use of all the well-known documents and of numerous little-known ones, which are brought here into the discussion for the first time. By studying all these with the utmost care and acumen he has succeeded in throwing fresh light on several dark places and in solving various enigmas in the course of the affair. He will be the first to acknowledge that a great number of questions may still be asked which are probably destined to remain unanswered for ever. This, however, does not detract in any way from the great merit of having presented us with a wholly original view on one of the most important and interesting conflicts that has ever arisen in science. No one who wants to build up for himself a really justifiable opinion on this conflict can afford to leave the book unread.

Prof. de Santillana is a man of remarkable erudition, not only in the field of science and its history, but also in those of general history, literature, art and philosophy. With all these attainments merged into a general culture, one need not wonder that they appear in his writings again and again in the form of reminiscences and allusions which enhance the attractiveness of the story. However, I am sometimes afraid that the author tends to over-rate the intellectual capacities of the average reader.

The same remark applies to the numerous comparisons between certain aspects of Galileo's case and analogous situations in our own time. There are several allusions to contemporary American issues which the foreign reader may not always be able to appreciate. In so far as he is able to do so, however, he will admire the author's broad point of view, which allows him to present the process against Galileo as a particular case of a perennial conflict of scientific endeavour and social authority.

E. J. Dijksterhuis

A Guide to the Literature of Chemistry

By E. J. Crane, Austin M. Patterson and Prof. Eleanor B. Marr. Second edition. Pp. xv+397. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 74*s*. net.

WHEN the first edition of "Crane and Patterson" was published in 1927, it was, with the exception of the much slighter "Introduction to the Literature of Chemistry" of Dr. F. A. Mason, published three years earlier, essentially a pioneer work. It quickly met a recognized need and for a decade or more was unchallenged. If there are now other works that may meet the needs of British chemists more effectively, though probably not within two covers, that first edition also has given the names Crane and Patterson an honoured place in the literature of chemistry. It is no disparagement of the work that Prof. Marr and Dr. Crane have put into the preparation of what is virtually a new book to suggest that for British readers the second edition is unlikely to have the same appeal as the first: the changes arise out of the immense expansion of chemical literature, and considerations of space alone may well have dictated an appeal to the American chemist rather than to his British colleague.

The plan of the book is essentially unchanged and the chapter headings are unaltered, with the addition of new chapters on government publications and trade literature, but it is, as has been said, virtually a new book. Omission of the "Select List of Chemical Books" is the main change responsible for the reduction from 438 to 397 pages, and although it would have been impossible, within the limits of a single volume, to bring that list up to date, the book loses something of its appeal in consequence, and the first edition will retain some permanent value, particularly since in the treatment of historical literature the book is relatively weak. Criticism might be made on a few points of detail: for example, under biographical works, some help could have been given in tracing obituary notices, the indexing of which, to say the least, is often fortuitous. Nevertheless, this second edition, like the first, displays the full scope of chemical literature and affords sound guidance to British and American chemists alike in handling a literature search. R. BRIGHTMAN

Engineering Materials, Machine Tools and Processes

By W. Steeds. Third edition. Pp. xi+426. (London and New York: Longmans, Green and Co., Ltd., 1957.) 35*s*. net.

FOURTEEN years have elapsed since the publication of the second edition of this useful handbook of workshop practice. Various additions and alterations have been made to deal with newer processes and methods that have proved themselves during those years, and have increased the size of the book by twenty-five per cent. The pattern of the book is unchanged, except for a new chapter added at the end. This is entitled "Transfer Machines and Automation" and in only twenty-four pages deals with some of the ways in which mass production in machining processes can be made more automatic and handling-time saved. Almost all of the other chapters have had changes; some are merely minor changes of order and others are additions. In the chapter on ferrous materials reference is now made to isothermal transformation diagrams and hardenability, but the reference is probably too brief for the average reader to grasp fully the meaning of these topics. There are various additions to the non-ferrous alloys, including a page on titanium. This review is not the place to catalogue all the additions, but notable ones are the Merchant theory of chip formation and air gauging systems. A thorough revision of references has brought the book up to date and there are many improvements in the photographic illustrations.

K. J. PASCOE

Theories of Nuclear Moments

By R. J. Blin-Stoyle. (Oxford Library of the Physical Sciences, Vol. 1.) Pp. vi+89. (London: Oxford University Press, 1957.) 8*s*. 6*d*. net.

THIS work is essentially a reprint of the valuable article by the author in *Reviews of Modern Physics* of January 1956, augmented by a chapter sketching the experimental sources of information on nuclear moments, and an appendix on angular momentum states in quantum mechanics. To explain electromagnetic moments we should in principle start from the nuclear Hamiltonian and the form of the electromagnetic interaction. In fact, we have only rough ideas as to what these are, and even if they were known, accurate calculation would be very formidable. Thus the theory is at present at the stage of using obviously over-simplified models wherever they will work, the different models required being linked in only a very qualitative way. Anyone desiring a quick survey of this surprisingly successful process cannot do better than read the volume under review. The accounts of the various models and their applications are very brief, but an extensive bibliography allows details to be pursued in the original papers.

The reviewer would have welcomed some discussion of centre-of-mass effects. These appear explicitly only in connexion with the quadrupole moment of an odd-neutron nucleus on the single-particle model. The formula given corresponds to a classical treatment of core recoil, and the dubious nature of such a treatment is not mentioned.

It is to be hoped, of course, that the progress of research will in a few years render this first edition obsolete. For this reason the use of paper covers, and the associated low price, are all the more commendable. J. S. BELL

The BBC Naturalist

Edited by Desmond Hawkins. Pp. 96. (London: Rathbone Books, 1957.) 8*s*. 6*d*. net.

THE valuable part played by the B.B.C. in fostering the widespread and growing interest in British wild life is undoubtedly an important factor in helping to build up a large body of public opinion favourable to the idea of nature conservation. In such features as "The Naturalist", "Birds in Britain", and "Look", the B.B.C. has brought many naturalists of repute to the microphone or the television camera, and the popularity of such programmes is something of a phenomenon in this technically minded age. The reviewer may be thought slightly cynical if he comments that many people quite incapable of recognizing a chaffinch on their doorstep may be perfectly familiar with the private life of a family of great black woodpeckers inside a tree-trunk in Germany, through the medium of television. Such an anomaly may be an unavoidable result of bringing natural history into the sphere of mass entertainment or mass education. However, recognition of the ephemeral nature of the spoken word has led to this excellent

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publication, in which twenty-three broadcasting naturalists have written in their own personal styles of those aspects of Nature in Britain with which they are most at home. Peter Scott on painting waterfowl, Maxwell Knight on reptiles, James Fisher on tits and milk bottles, and Bruce Campbell on nest-boxes, with a score of others, are all here in print, helping us to enjoy and appreciate with fresh interest the wild life around us.

This book is well illustrated in colour and black-and-white, and at its moderate price deserves a wide circulation. R. W. HAYMAN

Malaysian Parasites, 16–34

Edited by J. R. Audy. (Studies from the Institute for Medical Research, Federation of Malaya, No. 28.) Pp. vii+471. (Kuala Lumpur: Institute for Medical Research; London: Crown Agents for Oversea Governments and Administrations, 1957.) 42*s*.

THIS book comprises a set of papers on arthropod ectoparasites together with two on the known hosts of Malayan parasites generally and a useful review of the literature. The first paper is an interim review of the non-anopheline mosquitoes. (The propriety of treating these as parasites rather than predators is discussed by the editor elsewhere in the book.) Most of the book deals with mites but there is a paper on fleas and one on ticks. The papers on mites cover a certain number of non-Malayan species. The whole is an impressive tribute to the very active researches which have been pursued in this area since the War. The editor and contributors deserve every congratulation. The work is well and attractively illustrated and produced, although it is clear from the method of presentation that its stiff covers are not intended to disguise the interim nature of much of the contents. The taxonomist's road is a long one and the end is not yet. Most of the groups considered are at the beginning of the period of emergent order which follows on primeval chaos. As an example, it has been estimated that at least fifteen years will be required to raise the taxonomy of the Malayan culicine mosquitoes to the level prevailing in better-known parts of the tropics. The further stages of recognition and analysis of species complexes and, still later, the infra-specific analysis of individual species have been reached in only a very few small groups. Nevertheless, this is a heartening record of work in progress and a valuable reference book which no medical entomologist (or student of the vertebrate hosts) should be without. P. F. MATTINGLY

Annual Epidemiological and Vital Statistics, 1954

Bilingual edition (French and English). Pp. 617. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 30 Swiss francs; 50*s*.; 10 dollars; 2,400 French francs.

THIS volume presents vital statistics for forty countries. Deaths by cause (International Abridged List, 1948) and the seasonal distribution of twenty-three major notifiable diseases are given in detail. A new section records the size and diversity of each country's medical services.

The proportion of all deaths due to senility and ill-defined causes is tabulated for the first time. Of the twenty countries listed Ceylon has the highest overall proportion, just under 20 per cent. France and Belgium have consistently higher proportions than England and Wales in each age and sex group.

The public health worker will find that this book raises some interesting queries. Why, for example, is mortality from accidental deaths (p. 378) higher in female than male infants in Northern Ireland, Finland, New Zealand, Japan and Ceylon, and lower in all others, and how can the high accidental male infant mortality-rate in Scotland be reduced?

Considering the complexity of the data the tables are well set out. It is, however, sometimes difficult to find the definition of a symbol. A few misprints occur, for example, 'explication' for explanation in footnote 6 (p. 53) and a transposition of the initial figures for the total and male population of the United States aged 65–69 (p. 27).

The most efficient use of the volume will be made by using it in conjunction with earlier numbers of this series. S. J. KILPATRICK

The Mathematical Theory of Epidemics

By Norman T. J. Bailey. Pp. viii+194. (London: Charles Griffin and Co., Ltd., 1957.) 36*s*. net.

IN the theoretical development of each subject a stage is reached where research is hampered by the lack of a unified and logical presentation of past work. This book meets that need for epidemiology. It presents the mathematical analysis of epidemics based on deterministic and stochastic models. The older deterministic approach to the subject, though less realistic, is shown to be a useful precursor to the more difficult probability methods. Chain binomial theory (first used by Greenwood and more recently by the author) gives encouraging results in the analysis of household outbreaks. Earlier models predict the damping of recurrent epidemics. These are now more accurately described by stochastic processes. A full bibliography is given.

The book stresses the need for suitable stochastic models of endemics and for the proper collection of data to evaluate the assumptions and results of the theory. To this end formulae are given for the estimation of the parameters used in each model. The practical difficulties of estimating such necessary constants as β, the infection-rate, are not considered.

While this book contains much of interest to public health workers such information is generally difficult to find in non-mathematical language. It is accordingly more suitable for biometricians. S. J. KILPATRICK

Family and Kinship in East London

By Michael Young and Peter Willmott. (Reports of the Institute of Community Studies.) Pp. xix+232. (London: Routledge and Kegan Paul, Ltd., 1957.) 25*s*. net.

THIS is the first of a series of reports issued by the Institute of Community Studies. It is based on interviews with 1,000 individuals living in Bethnal Green, London, a more intensive interview with forty-five married couples in that borough, and a study of forty-seven families originally living in Bethnal Green, but re-housed on the London County Council housing estate in Greenleigh. The first part of the study is concerned with kinship structure, and stresses in particular the important role of the wife's mother in the domestic life of the growing household. In the second part the authors study the reactions of families re-housed in Greenleigh and discuss the implications of their findings for future housing policy. The report is extremely readable, and combines the advantages of an anthropological field study with more rigorous statistical analysis. It is particularly welcome as an addition to the all too rare studies of normal family life in Britain to-day. E. GREBENIK

THE NATIONAL PHYSICAL LABORATORY

THE National Physical Laboratory held two open days, on May 14 and 15. One hundred and eighty exhibits were on view to 3,250 guests of the Laboratory, who came from industry, the universities and Government departments. It was the first time that the Laboratory had been on show since the divisional reorganization, announced last February. This year, as an experiment, the range of exhibits was somewhat restricted, because the items chosen were selected to display work in certain chosen topics. For example, the exhibits shown by the Light Division all fell into three topics: optical instruments and methods; standards and measurements of radiation, light and colour; and research on vision. Work which did not fit into the topics selected was, therefore, not on display, but arrangements were made so that it could be discussed with the responsible officers of the Laboratory.

The Aerodynamics Division is investigating the problems of hypersonic flow, that is, at speeds in excess of Mach 5. Several new aerodynamic problems arise at such speeds, including intense aerodynamic heating resulting in dissociation of the working gases and, if the temperature is high enough, their ionization. For this investigation, shock-tubes are being developed which operate for about half a millisecond; these obviate the problems of overheating the equipment. Surface temperatures and pressures are measured with rapid-response instruments and a schlieren optical system has been developed which records flow-density patterns around the test bodies using a camera of the Cranz-Schardin type (see Fig. 1). In addition to the shock-tube being used for the main programme of research, two small tubes have been constructed for work of a more fundamental nature on the properties of gases at high temperatures. One of these will be used to study the visible radiation spectroscopically in order to evaluate the gas temperature, the other to investigate the electron concentrations by means of micro-wave techniques. Some of the non-aeronautical work of the Division was displayed in the form of a small exhibition of models which had been tested in low-speed wind tunnels. There is a considerable demand for accurate information on the effects of wind on structures such as the B.B.C. television transmitting tower, suspension bridges, chimney stacks, blocks of houses and the aerial system of the University of Manchester radio telescope at Jodrell Bank. Similar work is carried out on the airflow around ships and buildings to ensure that the effluent from funnels and chimneys causes neither annoyance nor damage.

The Control Mechanisms and Electronics Division displayed a conditional probability computer. This is a form of 'learning machine'. It has five input channels and thirty-one units to store statistical information of the patterns presented by the inputs. When some statistical data have been accumulated in the storage units and one or more of the input channels is activated, the computer determines from the data whether such activation is usually accompanied by activity in one or more of the other input channels. If it is, the computer 'infers' that this activity is again present. The units which store the statistical information are counters which function by charging capacitors. These capacitors have deliberate slow leaks in parallel with them so that the computer's inferences are based more on later events than earlier ones. The demonstration showed the computer controlling a small mobile carriage which followed the boundary between black and white areas painted on the surface on which the carriage ran. The black and white areas could be effectively interchanged by reversing the steering mechanism, so making the computer learn the new conditions. It is hoped to develop the computer to a stage when it can function as an industrial control mechanism which will select optimum conditions by a trial-and-error learning process.

The Light Division has made significant advances in the techniques necessary to produce cheap, metrologically accurate diffraction gratings used for automatic machine-tool control. Gratings several feet long are being made by a photographic printing method of reproduction using the fine-grain emulsions already available in the Laboratory. Photographic techniques also open up the possibility of producing gratings directly from an interference pattern, so removing many of the possible sources of error in manufacture. The regularity of spacing would then depend entirely on the accuracy of the interferometer mirrors and the stability of the photographic emulsion during processing. This quite old idea, due originally to Michelson, has been made practicable by the development of both fine-grain emulsions and isotope discharge tubes used as monochromatic sources.

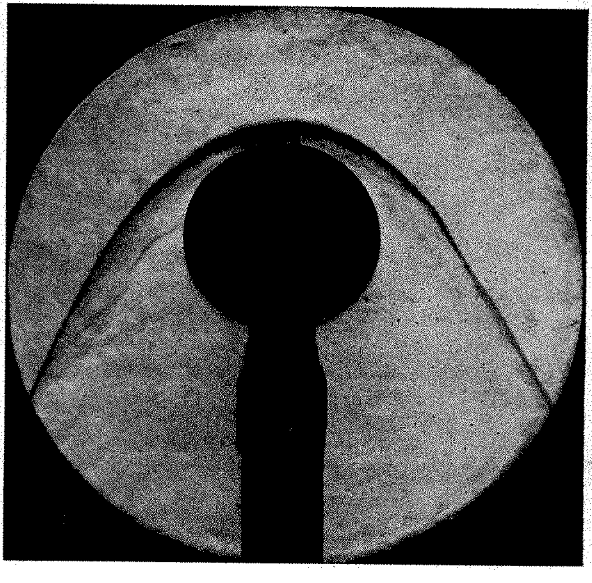

Fig. 1. Shock wave of flow around a sphere in the National Physical Laboratory hypersonic shock tube. Conditions (approximate): Mach 9 for equivalent altitude of 150,000 ft. and stagnation temperature of 6,000° K. *(Crown copyright reserved)*

Gratings 3 in. square with 30,000 lines per inch have been produced. Two gratings made in this, or a more conventional, way can then be arranged to produce moiré fringes while one of them, mounted on a carriage, moves over the other. The moiré pattern then controls the recording of a third grating mounted on the same carriage. This new grating is therefore smoothed by the integration produced by the moiré system over its effective aperture. Two such gratings are then used in the same system to produce another improved generation. In this way, the quality of the gratings can be improved until a limit is set by emulsion creep and considerations of mechanical and thermal stability.

In addition to these linear gratings, the Division demonstrated radial gratings with a moiré system to interpret angular movements. Eventually these gratings will be reproduced photographically, so providing the engineer with a simple accurate method of obtaining digitized information about both radial and linear movement.

The Mathematics Division exhibited DEUCE, its high-speed digital computer. The machine has solved some varied problems during the year, including work on cancer research, the examination of certain vibrational modes of molecules and the stability of aircraft in conditions of flutter.

The Metallurgy Division showed some work on the mechanism of brittle fracture. It has been found that brittle fracture occurs either by separation along grain boundaries or through crystals along cleavage planes. In the former case, two surfaces are formed from one previous interface, and the extra energy, corresponding to the difference between the new surfaces and the original interface, must be supplied for the fracture to occur. This energy difference is often a significant term; hence materials with low-surface and grain-boundary energies will have a greater tendency to fracture along the boundary than those with high energies. Experiments have been carried out with copper to which increasing amounts of antimony had been added. It was found that the addition of antimony reduced the interfacial energies of the copper—1½ per cent by weight lowers the energy by more than 80 per cent. It is thought, therefore, that the weakness at the grain boundaries can be associated with the effect of the antimony in lowering the interfacial energies of copper and, therefore, the energy requirements for fracture.

Niobium, with its high melting point, good strength at high temperatures and excellent ductility, is an attractive metal. It suffers, however, from the disadvantage that it easily absorbs gases at high temperatures, particularly hydrogen, with subsequent embrittlement. X-ray diffraction photographs of samples of niobium with known hydrogen contents have been taken. At low temperatures, some hydrogen is absorbed in niobium, and the rest is in the form of a hydride with a structure derived from the cubic lattice of niobium by a simple distortion. On heating, the degree of distortion diminishes and the hydride progressively dissolves in the niobium. At 300° C. a simple cubic solution of hydrogen in niobium remains. These changes may well have significant effects on the mechanical properties of the metal and on the amount of hydrogen contamination that can be tolerated.

The work of the two Divisions, Applied Physics and Basic Physics, was displayed under the common heading 'Physics'. There have been some advances in bomb calorimetry. The original National Physical Laboratory bomb calorimeter is unnecessarily precise for the determination of the calorific value of fuels, and the experiments conducted in it take considerable time. Hence, the Laboratory has built a copper aneroid bomb which dispenses with water as a thermal reference (Fig. 2). It needs only four temperature measurements in each determination and its lower thermal capacity enables experiments to be conducted more quickly. The aneroid principle is capable of high accuracy, and a third calorimeter with a silver bomb has been constructed to check the heat of combustion of benzoic acid, the common standard of all such determinations. The original calorimeter was recently used to measure the stored energy in graphite samples taken from the Windscale atomic pile by comparing the heats of combustion of irradiated and unirradiated samples.

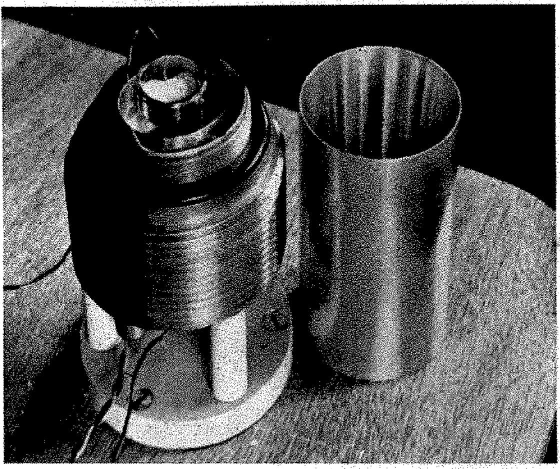

Fig. 2. National Physical Laboratory copper aneroid bomb calorimeter showing the platinum crucible, firing leads and shield (*Crown copyright reserved*)

An elegant multi-channel pulse-height analyser was displayed. This instrument, when fed with amplified pulses originating, for example, from a proportional counter, will produce a pulse-amplitude spectrum. It was built in collaboration with the Control Mechanisms and Electronics Division concurrently with a similar instrument made by the Admiralty Research Laboratory, Teddington. The analyser operates by converting amplitude to time and then passing the signals of different duration into different channels. It will also provide the difference between two inputs or subtract the background signal measured over the same time interval as the total signal.

Among other exhibits was a demonstration of a possible technique for measuring absolute temperature by determining the Johnson noise generated in a resistor. Such a 'noise thermometer' is theoretically capable of operating over a wide range of temperatures and pressures. Its accuracy is limited by the internal noise of the input valves of the amplifier. It appears that a comparison of noise voltages to 0·05 per cent may be possible, and a resistor has been built with a low enough leakage at 1,100° C. to exploit this accuracy.

Marine engineers need accurate methods of determining the actual power absorbed by propellers. The Ship Division showed a new torsionmeter which can be attached to propeller shafts of 2–6 in. diameter without having to unship the shaft. The instrument uses strain gauges arranged in a four-arm bridge attached by adhesive to the propeller shaft. The arrangement is such that it responds to torsional strains but not to bending strains. The signals are taken off the rotating shaft through silver-plated slip-rings and silver-graphite brushes. They are amplified and recorded on a null-balance strain meter. The ring assembly incorporates a revolution counter so that the rate of rotation of the shaft can be measured at the same time as the torque. The accuracy of the instrument is ± 1 per cent for torque determination and ± 0·2 per cent for speed of rotation.

The Standards Division incorporates the old Metrology Division and parts of the Physics and Electricity Divisions. It had a number of displays showing the value of interferometry, both optical and micro-wave, to science and industry. In 1960, the platinum–iridium bar which is the metric standard will probably be superseded by an 'intangible metre' defined as 1 650 763·73 times the wave-length *in vacuo* of the orange radiation of krypton-86. This standard will be not only reproducible in any laboratory, but also it is likely to be about a hundred times as precise as the present line standard. Interferometric methods used in conjunction with this new standard were demonstrated. The Laboratory announces the results of a new determination of the velocity of electromagnetic radiation—in this case not light but 4-mm. micro-waves. The velocity in free space *in vacuo* is 299 792·50 km. per sec., with a standard deviation of 3 parts in 10^7. The determination was made with a micro-wave interferometer which measured the wave-length of the radiation. The product of this and the frequency of the source, determined by comparing it with a quartz crystal standard clock, gives the velocity of the radiation. The actual distance over which the velocity was determined was only two metres. The result, with its applications to geodetic surveying, is a contribution to the International Geophysical Year.

To supplement the cæsium atomic standard of frequency, more accurate quartz clocks are required for long-term periods. Investigations have been carried out on the stability of a quartz Essen-ring operating at 4° K. Preliminary results suggest the damping is much reduced at this temperature and the temperature coefficient between 2° K. and 4° K. is less than 1×10^{-8}. The ring was immersed in liquid helium and the temperature was controlled to ± 0·001° K. by regulating the pressure. The stability of the oscillator may approach 1 part in 10^{11}. A problem to be solved is the replenishment of liquid helium without mechanical disturbance, and special liquid helium containers designed for this purpose were shown.

A. J. GARRATT

THE SPECIES CONCEPT AMONG VIRUSES

By Dr. C. H. ANDREWES, F.R.S., and Dr. P. H. A. SNEATH

National Institute for Medical Research, Mill Hill, London, N.W.7

THE term 'species' has been used to describe at least four different ideas:

(1) Linnæus's concept was close to the meaning 'a distinct kind of creature', that is, a group of organisms clearly separate from other groups of organisms, with no intermediates in between, and not itself divisible into distinct sub-groups.

(2) Geneticists consider a species as a 'genetic isolate' (with minor details of difference in definition) since—in organisms reproducing sexually—distinctness usually depends on absence of interbreeding with neighbouring forms.

(3) Palæontologists use the word in sense (1) extended in time, realizing that although obviously the species is continuous in time, with intermediate, ancestral and descendant forms, yet at any one instant the stock is distinct from others, no intermediates being extant.

(4) Systematists commonly use 'species' frankly as 'the most important rank in taxonomy below genus', and this must depend on subjective ideas as to what constitutes a genus, which (like the criteria for all higher ranks) are based mainly on intuitive estimates of degrees of similarity. Methods are, however, now being evolved for expressing this matter of similarity in a quantitative way[1,2].

There is as yet no general agreement as to which use of the term 'species' is best for general adoption. For viruses, however, only usage (1) can be seriously considered at the moment. Genetic recombination, a form of sexual reproduction, certainly occurs among viruses, but we simply do not know how common it is; we cannot therefore use the concept of genetic isolate at present in attempting to delimit species of virus. Many viruses are probably mutating and evolving more rapidly than higher organisms; at the same time, our knowledge of their past evolution is negligible; so usage (3) cannot apply. Ideas as to virus taxonomy are at present in an embryonic state, so we can as yet derive little help from usage (4).

Virus Nomenclature

At the last two International Congresses of Microbiology (Rio de Janeiro, 1950; Rome, 1953)[3,4], consideration has been given to virus classification and to the usefulness for viruses of a binomial system of nomenclature. As a compromise between two widely divergent views, a plan was put forward in Rome for a 'non-Linnæan' binomial system, provisional and less rigid than the orthodox system. Group names were proposed for some animal viruses and descriptions published: Myxovirus (Andrewes, Bang and Burnet[5]), Poliovirus (von Magnus, Gear and Paul[6]), Poxvirus (Fenner and Burnet[7]). Similar descriptions for a Herpesvirus group and for insect pathogenic viruses are in preparation.

Since their proposal in 1953 and the further publication in 1955, the names Myxovirus and Poliovirus have been widely used, but the 'specific' names have been practically ignored, almost as completely as have various comprehensive proposals for Linnæan nomenclature of viruses. It would appear that at the level of the 'group', which may be tentatively regarded as equivalent to 'genus', agreed names may be useful, but that there is little enthusiasm or demand for Latin names for individual animal viruses.

'New' Viruses

There are other cogent reasons for re-examining the matter. Since 1953, exploitation of tissue culture and other techniques has resulted in the discovery of very large numbers of 'new' viruses.

(1) *The Coxsackie viruses.* Small viruses pathogenic for suckling mice, and isolated most frequently from human fæces. These are classified into group *A* with nineteen serotypes and group *B* with five serotypes.

(2) *Echoviruses.* This term originally denoted 'enteric cytopathogenic human orphan' viruses, but this meaning is already almost forgotten. They are related to Coxsackie viruses but tend rather to be cytopathogenic in monkey kidney tissue cultures and innocuous to baby mice. Twenty serological types are already known, but the group is probably not a homogeneous one. One (Echo 9) has properties shared by both the Echo and Coxsackie groups. A recent tendency is to group Echo, Coxsackie and poliomyelitis viruses together under the name of *Enteroviruses*[8]. Similar viruses have been recovered from fæces of cattle, monkeys and pigs.

(3) *Adenoviruses,* with eighteen serotypes, have been mainly isolated from the respiratory tract of man; they share a common complement-fixing antigen and some have been depicted in orderly array within the cell nucleus.

(4) *Arborviruses.* This term covers the ARthropod BORne viruses. Dr. J. Casals and Dr. M. Theiler have in their collection about seventy-seven different ones. Rather less than half of them can be put into one or other of three sub-groups, *A*, *B* and *C*, mainly on the basis of antigenic relationships. The remainder comprise a very heterogeneous assortment.

In none of these three or four virus groups is it possible at present to see that it would be rational to make divisions into species. Let us consider Casals and Brown's *B* group of arborviruses[9]. All are related by tests involving hæmagglutinin inhibition. The group includes the yellow fever, West Nile, St. Louis, Japanese *B*, Murray Valley, Zika, dengue I, dengue II viruses and numerous others. Yellow fever virus would be considered by most people to stand apart on the basis of its pathogenicity for the primate liver, but there appear no other good grounds why it should do so. Murray Valley fever has been given a separate name largely because of its geographical distribution, but it differs no more from some strains of Japanese *B* virus than those do from each other. Dengue viruses are divided into two serological types, but these have almost as much right to specific names as have Zika, Ilheus and others of the *B* group. The inter-relationships within the group are, in fact, of all degrees of magnitude. To call each isolate by a separate geographical or other name could lead to as much confusion as happened in the genus *Salmonella,* particularly if there were any implication that such names indicated specific rank.

A few groups such as Myxovirus and Poxvirus have proved amenable to an attempt at binomial nomenclature, though even with them the matter is not straightforward. After five years, however, it does not appear that any other group of viruses suitable for similar treatment is in sight. We have made a very preliminary attempt to compare, and if possible group, twenty-five viruses by means of an objective quantitative method[1]. This tries to group organisms by expressing their similarities quantitatively; each virus is compared against each other virus and given a percentage score on the basis of the proportion of characters common to the two. We compared twenty-five viruses and made use of forty-nine characters, choosing for convenience—and despite minor logical objections—those in which we expected a reasonably even distribution of + and − answers: such characters were none too easy to find. There proved to be so many gaps in our knowledge that for most viruses we could score only about twenty-five of the forty-nine characters. Some of the viruses we chose were expected to fall together; for example, three poxviruses, three myxoviruses and four arborviruses; the others were rather heterogeneous.

The analysis was scarcely very revealing. Those viruses which we expected to fall close together mostly did so. The three myxoviruses lay close to each other; so did the four arborviruses, and along with them, not unexpectedly, that of lymphocytic choriomeningitis; herpes simplex and pseudorabies proved to be very similar. The only surprise was that the three pox viruses chosen, vaccinia, fowl-pox and myxoma, failed to show evidence of very close relationships. No significant groupings appeared where none had been perceived beforehand. The analysis would doubtless have been more valuable if we had included more viruses and particularly if we had had full information concerning many more properties suitable for comparison. Further studies in comparative virology would be very helpful, but as things stand it seems difficult to make further headway at the moment along the lines put forward at the Rome International Congress on Microbiology. We do not feel competent to discuss how far the same situation exists with regard to plant viruses, but we suspect that it is not very different. Bawden[10] favours Mayr's term 'collective species' to mean a collection of clones having many features in common; but this may in fact not be very different from the 'group' in animal viruses. He feels that to attempt to classify plant viruses on a phylogenetic basis is at present quite impracticable. No worker on bacteriophages, so far as we are aware, has felt that our knowledge is sufficient to justify an attempt at comprehensive classification in this field.

To return to animal viruses, a fundamental difficulty is this: some viruses, such as measles and mumps, seem to be clearly distinct stable entities, but among the welter of other viruses, largely newly discovered, and often of doubtful pathogenic importance, they appear to be exceptional. One would expect on several grounds that viruses are evolving rather rapidly[11]; when one finds that most viruses do not fit tidily into species one's suspicions are strengthened. When factors leading to evolutionary change have long been stable, species are revealed as discrete mountain peaks; the equivalent of subaerial denudation has worn away deep valleys between them by eliminating poorly adapted clones. Where evolution within a group is still highly active we can see only ill-defined pimples and corrugations on a plateau.

If virologists use the term 'species' for viruses they should be clear in which sense they are using it: at present, usages other than the Linnæan seem to us quite unrealistic. We go further and suggest that at the present time the species concept should not be applied to viruses at all; further knowledge may, of course, change our ideas. Bacteriologists nowadays are becoming equally doubtful as to the proper application of the word 'species' in their field. Many botanists regard Linnæan names as having a usefulness only in a limited sphere; in the field of experimental taxonomy other parallel terms are required[12].

What, then, can be done to name and identify viruses? Some method of escape is needed from the confusion which results when authors use unrelated series of initials such as *YSK, CA, CCA, JH, EMC*. Perhaps virologists should continue with the Rome proposals for group names: names such as Adenovirus, proposed by *ad hoc* committees, fit in with these very well. We may, however, be wise to cease to force upon viruses latinized 'specific' names; numbered serotypes do well enough at present for adenoviruses and echoviruses; other systems of naming may have to be devised for other groups. Perhaps we should hasten slowly, concentrating on defining and naming 'groups'; but, below the group-level, only making such improvizations as seem wise in our efforts to clarify and codify this rapidly expanding field of knowledge.

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CONTROL OF EVOLUTION IN MAN*

By Prof. C. D. DARLINGTON, F.R.S.
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WHEN Darwin published his "Descent of Man" in 1871 he thought it better to discuss what had happened in the past, with results that could be seen, rather than venture into discussing the future. This task he left to Francis Galton.

Galton began with a point of view on human evolution formed by his medical training, his African travels and his study of Darwin's work[1,2]. On the basis of the cell theory he took a view contrasted with Darwin's, both on the inheritance of acquired characters, and on the distinction between one-egg and two-egg twins[3].

He noticed that like mates with like in man and thereby creates self-sustaining breeding groups. He also studied the genetic component of fertility and intelligence, and applied this principle to the study of natural and sexual selection in different social classes. His method has been effectively developed to show that the decline of governing classes is hastened by their choice for wives of infertile heiresses[4,5]. Similarly, he discussed migration and its effects, always assuming that men have to make culture before culture can be said to make men. He concluded that "the human race has a large control over its future forms of activity . . . for it can gradually modify its own nature". Galton thus foreshadowed a genetic interpretation of the structure and also of the history of society.

To-day, a number of advances may be traced to Galton's work. Intelligence tests[6] have indicated that the less intelligent individuals and populations can now propagate their like faster than the more intelligent[7,8]. This has not happened before in history or, we may say, in evolution[9]. In Holland, the United States, Tasmania and England[10,11] they have shown that migration modifies the intelligence of a community. The most active farmers move on to the best land. They exercise discrimination. They select their environment. Similarly, the migration from country to town and, as Galton pointed out, from the provinces to the metropolis, is reflected in the educability of the children.

Another application of Galton's views is to fertility. On one hand, consider the Hutterites. By selection for fertility together with inbreeding they have raised their average from 9·2 to 10·9 children per family[12]. On the other hand, consider Ireland. In 1847 the population reached more than 8 million with a density equal to that of England and Wales. It had multiplied six-fold in less than 140 years. Following a loss by emigration in 10 years of 1½ million, the population of Ireland has been almost stable for fifty years at half its peak number. Emigration, it seems, has selectively lowered the fertility of the people who remained and thus has led to the uniquely low and stable birth-rate in Ireland to-day.

Classical Genetics

To a student of genetics to-day, Galton's theories seem to be well founded. But at the time they rested on a basis of incalculable heredity. The rediscovery of Mendel in 1900 might thus have been expected to strengthen Galtonian and Darwinian theory. It did not do so.

For Bateson, to be sure, Mendelism at once clarified certain primary issues[13]. For the first time it showed that hereditary variation was largely invisible. A man might suffer from too little pigment in the skin or too much pigment in the urine through heredity although no known ancestor had suffered from it[14]. Heredity could be seen as responsible for the unlikeness of brothers as well as their likeness. In disclosing these primary paradoxes suddenly Mendelism had magnified the genetic, at the expense of the environmental, component in all variation. Not only the cards but also the process of shuffling was a manifestation of heredity.

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* Substance of the Woodhull Lecture delivered at the Royal Institution on March 21.

Owing to the disputes between Bateson and the followers of Galton, however, the evolutionary aspects of the new advance were pushed into the background. The Mendelian design of experiment required pure lines and gene mutations of gross effect. Pure lines and gene mutations were therefore taken by Bateson, and later by Morgan, as the raw materials of natural variation. The model systems that resulted were easy to handle in theory but they gave an unconvincing account of natural variation, above all in man.

It was in this period that environmentalist explanations of human variation gained ground in the social sciences. Mendelism, unhappily using the word 'character' instead of 'variable', was too crude and naïve to explain the subtleties of human variation: they came to be left to the operation of spontaneous causes subsumed under the word 'culture'. It has even been argued that because culture can sometimes be socially *transmitted* it can never be racially or individually or genetically *created*[15].

Genetic Systems

Genetics has grown out of Mendelism in the past thirty years, by spreading down into the cell and up into the population. This growth has developed the paradoxes as well as the laws of heredity. In the breeding experiment we see the direct reaction of heredity with environment. In a fixed population we see what is there after the environment has selected the heredity. In a mobile population we see what is there after heredity has also, in its turn, selected the environment. The opposed agents are not independent: they interact in sequence; and the sequence with men and animals begins with a variable heredity.

Again, to the experimental breeder the unit of variation is the gene mutation. To the cytologist it may be an inversion or an interchange of a piece of chromosome; and to the naturalist it may appear as a polymorphism, a floating 'variety'[13].

The bringing together of these three methods of inquiry has now established that the bulk of natural variation is due to the mutually adaptive combining of mutations and structural changes; that the mutations themselves are of different orders of size; that in most of their activities they are the individually undetectable parts of multiple or polygenic systems; that genes expand or contract according to the size of the breeding group within which they are being exchanged. Not only this, but also polygenic systems are adapted to the range of variation of the breeding group within which they subsist. Their evolution is therefore itself subject to changes in the size and character of the breeding group. Genes and genotypes are therefore related to breeding groups and have to be considered together with them in examining the evolution of any species[17,18].

This transformation may be illustrated in the most successful field of human genetics. For fifty years the study of blood group antigens has proceeded on Mendelian lines. It has led to the most detailed account of geographical variation known in any organism[19]. Gradually, however, the structural complexity of some of the genes or super-genes concerned has been predicted by Fisher, and demonstrated by Race[20]. Independently, their physiological complexity has been predicted by Ford[21] on the analogy of polymorphisms in other animals. This complexity has now been demonstrated with selective and evolutionary implications by statistical studies of their relations with susceptibility to disease[22].

Lately the hæmoglobin genes have shown how malarial diseases have forced whole races of men to modify the composition of their hæmoglobin as a means of avoiding extinction. To do so they have had to introduce an adaptive polymorphism more drastic than that known in any other animal[23,24]; comparable indeed only with that of hybrid species of plants.

These relations, paradoxical or dialectical as they may be, mean that we have to begin our study of evolution in any organism farther back than we had thought necessary. In man we first have to examine the history of his breeding groups. Fortunately, however, they are better understood than those of any other organism.

Human Breeding Systems

For some thousands of generations until recently, man has been spreading over the Earth as, by his own evolution, larger areas became profitably occupiable by him. He still exists in simple societies the breeding habits of which, since they are found in all continents, are assumed to correspond with those of his common ancestors. Mating is limited not by his immediate fertility but by self-imposed rules rejecting at once close inbreeding and wide outbreeding[25].

The repugnance for outbreeding is, of course, common to all life. It has merely become more discriminating in man. The repugnance for inbreeding, on the other hand, is new. It has demanded more than discrimination. It must have arisen either from the experience (which is universally true) that unusual inbreeding yields an unusual proportion of defective recessive types in the offspring; or from the selection of races in which an instinctive reaction took the place of such an intelligent inference.

The combination of outbreeding and inbreeding must have always had, as it has to-day, a precise effect on the mating groups in which man exists. The effect is comparable only with what arises from the incompatibility of plant systems[26]. It means that within these groups three special properties will be favoured: hybridity, recombination and uniformity. We expect, and we seem to find, that where the group is small and stable these properties are soon established.

All these properties, it would seem, favour the immediate welfare of the group. They have, however, one important consequence for the future of the group: it is to discourage any genetic cleavage within it so long as its members live within range of one another. The group is homogeneous and its homogeneity is preserved by the outbreeding rules. Differentiation in social function, in occupation, will arise between the sexes and between young and old; but it will not arise spontaneously between genetic sections within the mating group. Pairs of such societies in Australia may even fuse and combine their marriage rules to allow of a new uniformity in the enlarged group[27].

In advanced societies we have parallels with the endogamy and exogamy rules of primitive societies. Neither, to be sure, is so rigorously maintained; and the breeding groups established can be shown, over thousands of years, to be of varying stability. But they are fundamentally contrasted with those of primitive societies in one respect. They are horizontally stratified in groups or classes which meet but do not mingle. These classes, which come to work and think and speak[28] differently, co-operate by virtue of genetic differences which they preserve by not interbreeding.

To the rule that social classes cannot be preserved if they freely inter-marry there is one legendary exception, the Natchez Indian tribe. But the four classes described could not, in fact, have maintained themselves even in numerical balance if they had followed the rules attributed to them[29].

The development of social classes, beginning at the neolithic stage, has followed different lines in the main areas of civilization. Hinduism, Judaism, Islam and Christianity have diverged in their effects on the breeding system. Most striking is the contrast between India and the Middle East. In India a unity of religion prescribes a diversity of 'breed' or 'caste'. In the Middle East, since the triumph of a tolerant Islam, a multiplicity of religions guarantees a multiplicity of professional breeding groups. Underneath this contrast, however, the genetic principle is uniform. It is also quite distinct from the automatic systems of genetic caste distinction in the Hymenoptera[30]. Inter-fertile classes which work together without breeding together uniquely distinguish advanced human societies from all other forms of animal life.

If the breeding systems of primitive societies always favour uniformity or homogeneity in their genetic structure, how has stratification come about in advanced societies ? One source is to be found in the nomadic communities of the Middle East. Tribes where sheikhly and slave castes are undeveloped have become different in their genetic character. Their differences are shown first in their mental and emotional character, and by derivation in the kind of work they do and the skill they acquire in it. From this differentiation of tribes their co-operation and commerce arise by agreement[31].

Such co-operation of racially different people has evidently been one of the bases of class differentiation wherever craftsmen and sailors, merchants and missionaries have wandered and settled[15]. But the foundations of class structure have been laid as much by conflict as by friendship. Governing classes owe their origins largely to conquest. Agriculture owes its development largely to slavery, and slavery also largely arises from conquest or piracy. "Bondmen" shall be "heathen" and "strangers" (*Leviticus*, xxv, 44–46).

On this view, introduced genetic differences, whether racial or tribal, have sown the seeds of social differentiation and the co-operation of dissimilar individuals out of which the richness of human cultural development has arisen. How have these seeds germinated ? All stratified societies that have survived have permitted a limited inter-breeding between the groups : slaves could be freed, freemen ennobled and the Brahmin's offspring might sink to a lower social level. By legislation and by direct action, Roman emperors and Indian kings have controlled these processes with the intention of controlling evolutionary change. The development of class society has depended on the mixture of the materials brought together in this way, mixture subject to processes of mating, promotion and migration, all of them socially selective, and selecting differently in different societies.

In India, after some mixture leading to the formation of new hybrid castes, inter-breeding has often ceased. The genetic processes of diversification of a society have thus fossilized at a stage not far removed from racial mixture. In the U.S.S.R. and America strictly racial classes can exist together with a theory of classlessness ; and old classes can dissolve side by side with a crystallization of a new class structure which predictably reconstitutes itself.

In these changes we know how valuable the mixture of groups must be in providing the recombination which releases variability. Conversely, how valuable a restriction of mixture must be, follows from the Mendelian principle that one act of crossing can undo the work of a hundred generations of faithful inbreeding. A steady release of variability, therefore, demands a restriction of crossing. If a small group like the Greek merchants of Chios[32], the Quakers in England or the Hutterites in Alberta were to preserve their character they had to inbreed. Thereby they reinforced the homogeneity of that character, their consciousness of it, and often their desire to preserve it.

On this genetic view our advanced societies are more complicated than anything envisaged by Galton. They are not races in an animal or plant sense. They are differentiated nations. Their differentiation may be appropriate or inappropriate to the needs of the time and in this we may see the genetic component in the rise and fall of empires. The differentiated classes may begin by differing on the surface ; but they end by differing more under the surface like the cryptic species of plants and animals. Their ability to keep apart maintains civilization while their ability to mix allows evolution and promises survival.

Control of our Evolution

Man throughout his history seems to have been interfering with his evolution by most of his political acts and his social habits. What has been unconscious is bound now to become conscious. As we study the consequences of our actions we shall correct them ; and as we introduce new actions we shall already be aware of their consequences.

How much do we know ? We know that change in our breeding system has the effect of creating visible diversity of form. We know little of its effect on the invisible variables : intelligence and fertility, viability and resistance to disease. In our own population, I find, a change from outbreeding to inbreeding leads, as in other organisms, to depression, especially affecting the invisible variables. But it provides the means of rapid improvement, if we want improvement.

On the simpler Galtonian selective level the development of medical science has upset the world's population in quantity and also in quality. The qualitative changes affect race as compared with race, class as compared with class, and individual as compared with individual. Medical treatment of most genetic disabilities, except lack of intelligence, enables those who have been treated to survive and to reproduce when they would not otherwise do so. Those who were saved as children return to the same hospital with their children to be saved[33]. In consequence, each generation of a stable society will become more dependent on medical treatment for its ability to survive and reproduce.

Thus our control is changing the direction of evolution. We have to weigh its advantages and its disadvantages. Meanwhile, let us note a larger principle: every branch of government in its own field controls the evolution of the people it administers. The punishment of crime affects the reproduction of the criminal class. Education affects the mating groups of those who pass through the system. Taxation and subsidies affect the relative numbers of children born in the different social classes and can be adjusted to vary the results over a wide range.

The governments of Augustus and Claudius seem to have been aware of the effects of regulating genetic diffusion between classes. Modern authorities with their more drastic actions are unaware of such effects. They are unaware because the actions themselves are directed, not to breeding, but to the present life of the individual and the present economy of the State. New processes, however, which are directed to breeding, are now attracting attention. Such are ionizing radiation, sterilization and artificial insemination.

The classical geneticist is much impressed by the consequences of ionizing radiation in inducing mutations. When induced in the ripe sperm of *Drosophila*, and followed by two generations of brother–sister mating, these mutations lead to dire results. On man, living and mating at large, however, we do not yet know what the lasting genetic effects of such radiation may be[34]. So far as we can foresee, they would be like the effects of an increased frequency of cousin marriage in an unaffected population.

The inverse of this problem is shown us by the introduction of the practical measure of the sterilization of genetically, usually mentally, defective individuals. This kind of evolutionary control has been used for sixty years in the United States and for thirty years in Scandinavia. Here is one way, a negative way, in which governments are assisting in the propagation of intelligence. The practice is increasing[35].

A positive means of propagating intelligence is provided by artificial insemination[36]. When this technique was first introduced, pedigree cattle breeders foresaw great dangers to their own interests, and their foresight has been vindicated. The new method has undermined the value of the old criteria in cattle breeding. Now man, as we have seen, has a self-maintaining breeding system of a uniquely complex kind. It cannot be reduced to the steady formulæ of a cattle-breeding system. Artificial insemination from a donor (AID) is therefore likely to have more diverse consequences for man than for a domestic animal.

What are these consequences ? A third party is introduced into the control of the breeding process. If he is aware of its genetic consequences he may, like the Russian landowner who bred his serfs for beauty[37], be able to render a service to society. Moreover, since his activities are likely to be limited to the remedying of sterile marriages, we shall have time to judge their results before any danger arises from them. But if his results are secret there will never be any possibility of assessing or correcting them.

There is one respect in which assessment would be useful. In the past, the rigidity of human breeding systems has been mitigated by illegitimacy. From William the Conqueror to Abraham Lincoln, illegitimate class-crosses, such as rarely arise through marriage, have produced men out of the common run[38]. In advanced societies illegitimacy is declining; but through artificial insemination the laws of legitimate, that is, assortative, mating might be evaded with advantage to the community. For single individuals can alter the course of history or of human evolution.

The Future

Man controls his own evolution by two general methods. One is through the selection which changes the character of the world's population in every generation. The other is through the processes of inbreeding or outbreeding by which variability is preserved or released for selection to act upon. We now know we are interfering with both. It is a question of how we ought to interfere so as to do good and not do harm.

Most of the effects, good and bad, of any genetic policy can be felt only after the lapse of a generation. Moreover, the human breeding system is unique in its class basis, its elaborate discrimination, and its repugnance for outbreeding. Oppressed by closer fears, modern governments take less care for posterity than did their predecessors in antiquity. Governments which provide us with education have forgotten that only our parents can provide us with the ability to profit by it. There is indeed much evidence of a genetic component in the survival of nations. The nation which takes thought for its own genetical future is, therefore, most likely to have a future.

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NEWS and VIEWS

International Meteorological Organization Prize: Mr. E. Gold, C.B., F.R.S.

MR. E. GOLD, former deputy director of the Meteorological Office, has been awarded the International Meteorological Organization Prize for 1958 by the Executive Committee of the World Meteorological Organization, in recognition of his furtherance of the science of the atmosphere, his memorable contributions to the technology of weather forecasting, and his long and distinguished service to international collaboration in meteorology. The presentation was made by the president of the World Meteorological Organization, M. André Viaut, at the Royal Society's rooms on June 30.

Mr. Gold has been a leader in international meteorological work for many years, notably as president of the Synoptic Weather Commission of the International Meteorological Organization during 1919–47 and of the Meteorological Sub-Commission of the International Commission for Aeronautical Navigation during 1919–46. He also represented the Meteorological Office on three other Commissions of the International Meteorological Organization. The Synoptic Weather Commission, responsible for international uniformity in observing practice and for constructing the codes used for the international exchange of reports and forecasts, met on ten occasions and passed some 400 resolutions under Mr. Gold's presidency. This was a period of great increase in both the depth and breadth of meteorological practice as it was improved to use new knowledge of the atmosphere and to meet the requirements of users, notably aviators. In the more purely scientific field, Mr. Gold is well known for his pioneer investigation into the radiative equilibrium of the stratosphere, his work on the relation between barometric gradient and wind force, and his invention of the barometer correction slide and the visibility meter which bear his name.

The Prize consists of a gold medal bearing on one side the badge of the World Meteorological Organization and on the other the inscription: "*Societas Gentium Meteorologica. Pro singulari erga scientiam meteorologicam merito*", a diploma, and a sum of money. It is paid for from part of the interest on the balance of the funds of the International Meteorological Organization on the replacement of that organization by the World Meteorological Organization in 1950. The award is made annually by the Executive Committee from names proposed by member countries, and it is laid down that in the selection of the recipient both scientific eminence and the record of work in the field of international meteorological organizations are to be considered.

Mechanical Engineering at Liverpool: Prof. W. J. Kearton

PROF. W. J. KEARTON, who is retiring from the Harrison chair of mechanical engineering in the University of Liverpool, served his apprenticeship in the Naval Construction Works of Vickers, Sons and Maxim at Barrow-in-Furness and was awarded in 1913 a Vickers scholarship to the University of Liverpool. After completing his studies at that University, he returned to Vickers, but in 1919 was appointed lecturer in mechanical engineering at Liverpool. He was promoted to a senior lectureship in 1937, a position which he occupied until 1947, when he succeeded Prof. G. E. Scholes as Harrison professor. While with Vickers, Kearton formed an attachment to heavy mechanical engineering which has remained one of his chief interests and to which he has made considerable contributions. His papers have been mostly concerned with steam-turbine design and he was at one time closely associated with the development of the mercury vapour–steam cycle. His books on steam turbines and on turbo-blowers and compressors are highly esteemed both by industrialists and by teachers of engineering, and his book on turbo-blowers has appeared in a German edition. During his long and distinguished career at Liverpool, Kearton never sought the limelight, but his qualities as an engineer and as a teacher have won the respect of colleagues and students alike. His students, in particular, have often paid tribute to the sympathetic and kindly help and guidance which he freely gave on so many occasions. He was chairman of the North-Western Branch of the Institution of Mechanical Engineers during 1948–50, and also served on the Council of the Institution during that period.

Prof. J. H. Horlock

DR. J. H. HORLOCK, who has been appointed to succeed Prof. Kearton, was a scholar of St. John's College, Cambridge, during 1946–49 and took first-class honours in the Mechanical Sciences Tripos in 1949. He then joined the staff of Rolls Royce, where he spent two years on aero-engine design and development. In 1952 he returned to Cambridge to read for a Ph.D. degree, and joined the staff of the Engineering Department as a University demonstrator, being promoted to University lecturer in 1956. During 1954–57 he was a Research Fellow of St. John's College, and in 1956 went to the Massachusetts Institute of Technology for a year as a visiting assistant professor in the Mechanical Engineering Department. Dr. Horlock's research work has been connected with the fluid mechanics of turbomachinery and he has specialized on the theory of flow in compressors and turbines, making a number of contributions to the theory which have been published in the Aeronautical Research Council Reports and Memoranda series, and Current Papers. He published some experiments and theory on the secondary flow in pipe bends in the *Proceedings of the Royal Society* and he has also published papers on properties of steam and on the Field cycle. Dr. Horlock is at present engaged on a book on the fluid mechanics of axial flow compressors, which will be published shortly.

The Royal Society: Research Fellowships

THE Committee representing the Royal Society and the University of Sheffield has appointed Mr. K. Dalziel as Sorby Research Fellow from October 1, to work in the Biochemistry Department of the University of Sheffield on biological kinetics. The Committee representing the Royal Society and the Armourers and Brasiers' Company has appointed Dr. T. E. Faber, of Corpus Christi College, Cambridge, as Armourers and Brasiers' Company Research Fellow from October 1, to work at the Cavendish Laboratory, Cambridge, on the electronic properties of liquid metals. Under the terms of the scheme to commemorate the late Lord Rutherford of Nelson, the Council of the Royal Society has appointed Dr. R. C.

Kumar, now working at the National Research Council of Canada, to be Rutherford Scholar for three years from next November, to carry out studies on elementary particles at University College, London.

Ciba Foundation Awards

An advisory panel of the Ciba Foundation has considered sixty-two papers from nineteen countries for the Ciba Foundation's Awards for 1958 for research relevant to the problems of ageing, and the following have received awards (the names of leading authors only are given): Dr. R. J. Boucek (Miami), Dr. D. S. McLaren (Mwanza, Tanganyika), Dr. A. Comfort (London), Dr. L. O. Pilgeram (Minneapolis), Dr. H. Sobel (Los Angeles), Dr. Z. Hruza jointly with Dr. E. Holečková (both of Prague), Dr. K. Walter (Giessen, Germany), Dr. A. A. Hürlimann (Bern), Dr. M. Murakami (Maebashi City, Japan). These awards are being offered for a fifth and final time in 1959, the closing date for entries being January 10, 1959, and further information may be obtained from the Ciba Foundation, London.

Darwin-Wallace Centenary

At a meeting of the Linnean Society on July 1, attended by members of the Darwin and Wallace families, representatives of other societies and institutions and members of the Linnean Society, the president, Dr. C. F. A. Pantin, unveiled a plaque in the meeting room commemorating the centenary of the reading before the Society on July 1, 1858, of the joint communication by Charles Darwin and Alfred Wallace on their theory of evolution by natural selection. At the meeting a hundred years ago neither Darwin nor Wallace was present: Darwin because of family bereavement and illness, and Wallace was still in Ternate. The papers were communicated by Sir Charles Lyell and Dr. (later Sir) J. D. Hooker, and as was the custom were read by the secretary. Hooker, writing to Francis Darwin at a later date giving an account of the meeting, said, "I was present . . . said something impressing the necessity of profound attention to the papers and their bearing on the future of Nat. Hist., etc., etc., but there was no semblance of discussion. The interest excited was intense, but the subject too novel and too ominous for the old School to enter the lists before armouring. It was talked over after the meeting, 'with bated breath'. . . ."

The papers were received by the secretary of the Society on the day before the meeting with a covering letter from Lyell and Hooker, and no prior notice of their title or contents was known to the Fellows before the meeting. They contained the first and quite independent statements of the great principle of natural selection. In both cases the discovery was the fruit of their profound experience of tropical nature while they were still young men. In further commemoration of this centenary the Society held a dinner in the Drapers' Hall on the evening of July 1, and on July 15, at a special meeting to be held at the Royal Geographical Society, some twenty Silver Darwin Medals will be presented to British and foreign biologists in recognition of their outstanding contributions to our knowledge of evolution.

Two Nuclear Reactors at the Atomic Weapons Research Establishment

HORACE, a zero energy reactor, is now operating at the Atomic Weapons Research Establishment at Aldermaston, Berkshire. It is being used for the study of the nuclear characteristics of a light-water research reactor, and consists of an arrangement of enriched reactor fuel in ordinary water. It will be used to investigate different types of reactor core arrangements and the use of different materials as 'reflectors' (to reflect neutrons back into the core). Work with it should enable the time taken for full commissioning of a second Weapons Group reactor of the same class to be materially shortened, since it will provide data relating to the control, safety and core arrangements of this type of reactor. This second reactor at Aldermaston, named HERALD, is being built by A. E. I.–John Thompson, Ltd., and should be completed by the autumn of this year. This will also have ordinary water as a moderator and coolant, will operate at power-levels up to five megawatts and will be used for research with neutrons and for the production of special isotopes. There are now thirty-five reactors either in operation or under construction in the United Kingdom for research, testing and power production.

Oak Ridge Research Reactor

A new research reactor at the U.S. Atomic Energy Commission's Oak Ridge National Laboratory has been successfully operated at its design power-level of 20,000 kW. of heat. The reactor, called the Oak Ridge Research Reactor (ORR), was brought to design power on May 29 after the power-level was raised in incremental steps over a period of several days while various operational tests were carried out. Operational testing is continuing. The reactor was designed to operate normally at 20,000 kilowatts, but may be operated at 30,000 kilowatts during some periods to meet the needs of the experimental programmes. The ORR will be used for fundamental research and engineering studies. The research programmes to be carried out in connexion with the reactor will include engineering studies on the effects of nuclear radiations, basic studies on the properties of metals, alloys and ceramics, and experiments involving neutron spectroscopy. The reactor also will be used for limited production of both short- and long-lived radioisotopes, many of greater specific activity than is now possible through other reactors available at the Laboratory. The ORR is a heterogeneous reactor, moderated and cooled with demineralized water. It has an average flux greater than 1×10^{14} neutrons per square centimetre per second, and has a beryllium-reflector core which utilizes fuel elements of uranium–aluminium alloy clad with aluminium.

Plutonium for Bombs

In the House of Commons on June 24, the Paymaster-General, Mr. R. Maudling, said that at the request of the Government, the Central Electricity Generating Board had agreed to a small modification in the design of Hinkley Point and of the next two stations in its programme so as to enable plutonium suitable for military purposes to be extracted should the need arise. The modifications would not in any way impair the efficiency of the stations, and as the initial capital cost and the additional operating costs would be borne by the Government, the price of electricity would not be affected. The country would thus be provided, at comparatively small cost, with an insurance against possible future defence requirements.

British Cotton Industry Research Association

In replying to a question in the House of Commons on June 24 as to whether he was satisfied that the British Cotton Industry Research Association was adequate to the present needs of the cotton industry, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Association provided an excellent example of progressive development and had achieved the confidence of the industry and a high international reputation. The Lord President had recently visited the Institute and was confident that the Council and Director of the Institute would continue to direct their programme of research effectively to those problems the solution of which would be of the greatest benefit to the cotton industry. Last year's grant to the Institute exceeded £84,000, and if the industry contributed more, the Government would increase its grant by £50 for every £100 extra from the industry.

Grants for Special Research

In reply to a question in the House of Commons on June 24, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that the Department of Scientific and Industrial Research was advised on grants for special researches by the Research Grants Committee of the Council, though the Committee may seek the advice of outside referees on any application. The chairman of the Committee is Prof. P. M. S. Blackett, and the chairman of the University Grants Committee and the Physical and Biological Secretaries of the Royal Society sit as assessors. Grants for nuclear physics this year amounted to £330,000 compared with £192,000 last year, and grants for other research has grown from £80,000 two years ago to £155,000 last year and to £320,000 this year.

Committee on Awards to Students

On June 25, the Minister of Education, Mr. Geoffrey Lloyd, in a written answer, announced that he and the Secretary of State for Scotland had decided to set up a Committee "to consider the present system of awards from public funds to students attending first degree courses at universities and comparable courses at other institutions and to make recommendations". The Committee would therefore consider the kind of awards to be made from public funds, the method of selecting students for such awards, and the principle of the hardship test required by the law as it now stands. Sir Colin Anderson has accepted the Government's invitation to act as chairman, and the other members of the Committee are: Mrs. Gladys Buxton, Mrs. Margaret Cooke, Mr. McL. Dewar, Miss J. A. Evans, Mr. W. W. Finlay, Mr. Norman Fisher, Alderman J. W. F. Hill, Mr. H. D. P. Lee, Dr. D. W. Logan, Mr. Ron Smith, Dr. L. S. Sutherland, Prof. Brinley Thomas, Dr. J. Topping, Mr. A. H. Wilson and Prof. E. M. Wright.

Research and Development in India

The third annual report and statement of accounts of the National Research Development Corporation of India, covering the year ended March 31, 1957 (pp. 17. New Delhi, 1957), records a steady expansion in activity. Seven new licences, including one development licence agreement, were negotiated and four new development projects involving an expenditure of Rs. 2.21 lakhs were sanctioned. A pilot plant was designed for de-ionization of cane juice, and experiments to determine the most suitable resins were expected to be complete by the end of the 1956–57 sugar season. Encouraging results were obtained in preliminary experiments on the production of copper chlorophyll from spinach leaves, and pilot-plant trials on the production of synthetic pine oil were conducted at the Shri Ram Institute for Industrial Research, Delhi. Encouraging preliminary reports have been received on the experimental infant food produced from buffalo milk at Kaira District Milk Producers' Union, Ltd., Anand, and a pilot-plant project for the production of phthalic anhydride by the fluidized-bed oxidation of coal-tar oil has been approved at an estimated cost of Rs. 2 lakhs.

Historical Documents

The library of the American Philosophical Society has acquired from time to time a number of interesting documents. Some of these are described in its *Proceedings* (**101**, No. 6; December 1957). The chapter on some newly obtained botanical papers is largely factual, but an illustrated account of sketches by T. R. Peale (1799–1885) is delightful. Another illustrated chapter deals with Augustin Dupré's sketches for medals, while yet another describes the so-called 'waggon affair' in which Benjamin Franklin took part in 1755. This "Wagon Broadside", the rarest of Franklin publications, was only acquired by the library last year. Another chapter describes a hoax on Dr. Franklin. The volume concludes with an account of Halliday Jackson's journal. Naturally, much of the material in this number is mainly of concern to Americans, but none the less there is much good reading of general interest to everyone.

A Hypothesis of Developmental Selection

From a study of lethal and semi-lethal mutants of the cruciferous plant *Arabidopsis thaliana*, J. Langridge has been able to advance a hypothesis of developmental selection (*Australian J. Biol. Sci.*, **11**, 58; 1958). Attention is directed to internal factors of selection and to barriers imposed by ontogenetic development as they may affect the degree of survival of newly arisen harmful mutations. The hypothesis states that "the survival of such mutant genes to the stage of germination depends on the diffusibility of the metabolite required by the mutants and the ontogenetic stage at which it is required. As a corollary of the hypothesis, those lethal mutants of flowering plants that appear after germination should, with certain predictable exceptions, have requirements for low molecular weight substances which may be supplied from external sources". In an experimental test of the hypothesis, the requirements for normal growth of eleven lethal or semi-lethal mutants were examined. The author reports that the six 'reparable' mutants require the following: (1) thiamine; (2) choline; (3) coconut milk; (4) sucrose or glucose; (5) a high osmotic pressure; (6) an alternation of temperatures for flowering. Of the five 'irreparable' mutants, (1) has decreased embryo growth; (2) lacks cotyledons; (3) lacks chlorophyll; (4) and (5) lack chloroplasts. The author considers that the behaviour of these mutants is generally in accord with the hypothesis.

Nitrogenous Components of Tracheal Sap

E. G. Bollard has investigated the composition of the nitrogen fraction of the tracheal sap in apples with the following results (*Austral. J. Biol. Sci.*, 10, 279; 1957). Organic nitrogenous compounds accounted for most of the nitrogen present. Aspartic acid, asparagine and glutamine were quantitatively the most important compounds; glutamic acid and other amino-acids were also present as well as a peptide-like substance. While apple variety, rootstock or manurial treatment may have had effects on the level of nitrogen in tracheal sap, they seem to have had little effect on the proportions of the nitrogenous compounds present. Through the growing season, however, there was a definite change in the proportions of some of the constituents. The composition of the soluble nitrogen fraction of leaves and fruits showed distinct differences from the composition of tracheal sap.

Egg Rafts of Angler Fish

The common European angler fish, *Lophius*, lays its eggs in long mucoid rafts which float on the surface of the sea as ribbons 2-3 ft. wide and 25–30 ft. long. In all the related species of which anything is known of the breeding, similar rafts appear to be formed, always with scrolled ends characteristic for the species. This is true of the various batfish, frogfish, goosefish and monkfish of American waters. In a recent paper (*Bull. Amer. Mus. Nat. Hist.*, 114, 333; 1958) Miss P. Rasquin has described the structures which produce these egg rafts, the rafts themselves, and the embryology of two species, *Antennarius* and *Histrio*, from the Sargasso Sea. In these species the two ovaries are fused in the mid-dorsal line and form together a single tightly scrolled ribbon, with double curvature. There is a single lumen, while the germinal epithelium is only present on the inside surface of the scroll. Tufts project into the lumen, terminating in each branch, during the breeding season, in a ripening ovum. At the time of ovulation the whole epithelium lining the lumen secretes rapidly, during the course of a single day, a mass of mucoid material; then the ova are ovulated into this mass, coming to lie in the spaces in the mass formerly occupied by the tufts. Peristaltic movements of the ovarian wall force the mass out through the cloaca, centre first. There is a rapid intake of water through the pores which represent the spaces occupied in the ovary by the bases of the tufts. In the presence of a courting male the sperm is carried into the raft in this intake of water and fertilization takes place inside the raft. Each egg thus lies free in a separate compartment within the raft in communication with the outside sea-water. The raft itself is an enlarged replica of the internal surfaces of the ovarian lumen. Rafts can be produced with great rapidity, as many as twenty-five being produced in the course of a three-month breeding season. The early embryology as described in this paper seems very strange and requires further elucidation.

Contemporary Formation of Dolomite

One of the most intriguing problems of sedimentary geology is the mechanism by which the mineral dolomite (the double carbonate, $Ca.Mg(CO_3)_2$, as opposed to mixtures or solid solutions of calcium carbonate and magnesium carbonate) is formed in Nature. Dolomite has been an important rock-forming mineral, and with it there are often found types of fossils which suggest that it was formed in warm, shallow, marine waters. On the other hand, true dolomite has only been found in modern marine sediments in very minor quantities; also, attempts to synthesize the mineral in the laboratory at ordinary temperatures and pressures have so far been unsuccessful. Some fresh light has recently been shed on the problem by A. R. Alderman and H. C. W. Skinner, who describe, in the *American Journal of Science* (255, 561) of October 1957, sediments containing appreciable amounts of dolomite which are being formed to-day in saline lakes in the coastal region near Kingston, South Australia. The occurrence of dolomite in saltpans has been reported before; the particular significance of the present report is that it has been shown that the composition of the lake-water is essentially that of sea-water in various degrees of dilution and concentration, and that the precipitation of crystalline dolomite has been clearly related with elevation of *p*H at seasons when plant-growth is especially active. Similar deposits are said to be forming in the Coorong, an attenuated gulf linked to the sea at the mouth of the Murray River. The authors suggest that the region would repay a more intensive study.

Sulphur Dioxide in Atmospheric Chemistry

Sulphuric acid is a major destructive constituent of smoky fog. It has long been believed that it was produced by oxidation of sulphur dioxide in the atmosphere, but little evidence on the reality of the oxidation was available. The matter has now been clarified by experiments carried out by Chr. E. Junge and T. G. Ryan of the U.S. Air Force Cambridge Research Center, Bedford, Mass. (*Quart. J. Roy. Meteor. Soc.*, 84, 46; 1958). They found that oxidation of sulphur dioxide can occur in dilute solutions in the presence of ammonia. Other substances, for example ferrous chloride, can also act as catalysts but are not found naturally in the atmosphere. The process stops after the *p*H value in the solution falls to about 2·2. Reference is also made to unpublished work by E. R. Gerhard showing that sulphur dioxide can be oxidized in the air to sulphur trioxide in strong sunlight without presence of water droplets and ammonia, but no general conclusion can yet be made as to the relative importance of the two processes.

Gairdner Foundation: International Awards

The Gairdner Charitable Foundation (Ontario), Canada, which was founded in 1957 and derived its funds from personal gifts of Mr. J. A. Gairdner, a Canadian industrialist and financier, and members of his family, has established two international awards, to be made for the first time in 1958: *The Gairdner Foundation Award of Merit*, a prize of 25,000 dollars to be awarded not more than once every four years to the individual or group of individuals who has made the most outstanding discovery or contribution in the fields of the arthritic, rheumatic and cardio-vascular diseases; and *The Gairdner Foundation Annual Awards*, comprising a series of prizes of 5,000 dollars each to be awarded in any one year to not more than five individuals who have made outstanding discoveries or contributions in the same field. Awards will be made at the discretion of the Foundation and will not be open to application on the part of potential

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candidates. The purpose of these awards is to confer signal and substantial recognition upon individuals whose recent work constitutes tangible achievement in the fields of the arthritic, rheumatic and cardiovascular diseases. Winners will be free to make personal use of their prizes in any manner of their choice. Awards may be made without restriction as to nationality and will be payable in Canadian funds. Recipients who accept an invitation from the Foundation to participate in scientific meetings in Toronto or to visit professional colleagues at research or academic institutions in other countries and as a result incur travelling expenses may have the amount of their award increased appropriately.

Second International Conference for Analogue Computations

THE Second International Conference for Analogue Computations will be held at Strasbourg during September 1–9. There will be four sections: theoretical, mathematical or physical problems; analogue computation materials; diverse and similar applications; connexion between analogue computers and arithmetical calculators. Further information can be obtained from M. F. H. Raymond, Secrétaire Délégué Général de l'Association Internationale pour le Calcul Analogique, c/o S.E.A., 138 Boulevard de Verdun, Courbevoie (Seine), France.

University News:

Leeds

THE title of reader in civil engineering has been conferred upon Mr. E. Lightfoot. Dr. D. C. Munro has been appointed as lecturer in the Department of Inorganic and Structural Chemistry.

Liverpool

THE following appointments have recently been made in the University of Liverpool: Dr. H. Edels, to be reader in electric power engineering; A. Young, to be senior lecturer in applied mathematics; Dr. J. C. Willmott, to be senior lecturer in physics; Dr. R. Huby, to be senior lecturer in theoretical physics; Dr. H. B. N. Hynes, to be senior lecturer in zoology; Dr. K. McCarthy and Dr. K. R. Dumbell, to be senior lecturers in bacteriology; Dr. J. L. Braithwaite and Dr. E. W. Macmillan, to be senior lecturers in anatomy; Dr. J. Glover and Dr. H. K. King, to be senior lecturers in biochemistry.

London

THE following appointments have recently been made in the University of London: Mr. William Blackwood, pathologist at the National Hospital, Queen Square, to the University chair of neuropathology tenable at the Institute of Neurology; Dr. J. N. Cumings, clinical pathologist to the National Hospital, Queen Square, to the University chair of chemical pathology tenable at the Institute of Neurology.

Sheffield

THE following appointments have been made: Dr. C. B. Wilby (lecturer in civil engineering); I. Fells (lecturer in fuel technology and chemical engineering).

Announcements

PROF. B. C. P. JANSEN, lately director of the Nederlands Instituut voor Volksvoeding, has recently been made an honorary member of the Nutrition Society, in recognition of his distinguished contributions to nutritional science.

AN exhibition on "Palæontology and Evolution", sponsored by the Palæontological Association in conjunction with the Geological Survey and Museum, will be opened at the Geological Museum, Exhibition Road, South Kensington, London, S.W.7, on July 9. The exhibition will remain open for several weeks, from 10 a.m. to 6 p.m. on weekdays and from 2.30 p.m. to 6 p.m. on Sundays.

THE second Conference on Analytical Chemistry in Nuclear Reactor Technology will be held at Gatlinburg, Tennessee, during September 29–October 1. Further information can be obtained from C. D. Susano, Oak Ridge National Laboratory, P.O. Box Y, Oak Ridge, Tennessee.

THE second Australasian Conference on Radiation Biology will be held at the Cancer Institute, Melbourne, Australia, during December 15–18. Papers on relevant subjects are invited, and titles and a 250-word abstract should be in the hands of the Convener by July 31. Registration forms and other information can be obtained from the Convener, Dr. J. H. Martin, Physics Department, Cancer Institute Board, 483 Lt. Lonsdale Street, Melbourne, Victoria, Australia.

A SYMPOSIUM on Microchemistry will be held at the University of Birmingham during August 20–27. It is organized by the Midlands Section and the Microchemistry Group of the Society for Analytical Chemistry, under the patronage of the International Union of Pure and Applied Chemistry. Further information can be obtained from W. T. Elwell, I.C.I. (Metals Division), Ltd., P.O. Box No. 216, Research Department, Kynock Works, Witton, Birmingham 6. Envelopes should be marked 'Symposium'.

AN International Symposium on Atmospheric Diffusion and Air Pollution, sponsored jointly by the International Unions of Theoretical and Applied Mechanics and of Geodesy and Geophysics, will be held in Oxford during August 24–29. Participation is by invitation and some international unions and agencies will be represented by observers. The co-secretaries for the symposium are: Dr. F. N. Frenkiel, Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Maryland, and Prof. P. A. Sheppard, Department of Meteorology, Imperial College of Science and Technology, London, S.W.7, to whom any inquiries about the symposium should be addressed.

A SYMPOSIUM on Theoretical Organic Chemistry, arranged by the Chemical Society under the auspices of the Section of Organic Chemistry of the International Union of Pure and Applied Chemistry, will be held in London during September 15–17. The meeting commemorates the centenary of Kekulé's celebrated paper "On the Constitution and Metamorphoses of Chemical Compounds and on the Chemical Nature of Carbon" (*Annalen*, 106, 129; 1858), in which Kekulé developed ideas which first came to him during his stay in London. The discussion will be arranged under three main headings, "Chemical Binding and Structure", "Nucleophilic Reactions" and "Electrophilic and Homolytic Reactions".

THE ROAD RESEARCH LABORATORY

OPEN DAYS

OPEN days were held at the Road Research Laboratory on May 15 and 16, when the work of the Materials and Construction Division at Harmondsworth and that of the Traffic and Safety Division at Langley were visited by some 2,000 highway engineers, manufacturers of contractors' plant, police, road-safety officials and others in a position to make use of the results of the Laboratory's investigations.

Among the exhibits were methods devised at the Laboratory for testing motor-cycle crash helmets for protecting the wearer against fracture of the skull or concussion, and for ensuring that the peak of the helmet is not so flexible that it will flap in a fast-moving airstream nor so stiff as to present a hazard in the event of a crash. The British Standards Institution uses these tests to maintain the high quality of helmets bearing the 'kite' mark. Another display showed the technique for investigating injuries due to 'crashes'. With the co-operation of the police forces in the areas of Slough, Windsor and Staines, a team from the Laboratory proceeds to the scene of each accident and collects data on the circumstances, and on damage to the vehicles and injuries to their occupants or to other road users. The data may include pairs of stereo-photographs from which an accurate record to scale of skid marks and other visible evidence of events immediately prior to a collision can be obtained with plotting equipment. The many photographs shown illustrated the importance of the failure of vehicle seats or fixtures in aggravating injuries sustained by occupants of a car, and the importance of a yielding rather than a rigid design of steering wheel and column if a driver is to escape serious chest injuries in a collision.

Another group of exhibits consisting simply of defective parts taken from cars was frightening in its implications on safety—it included a steering-wheel assembly in which the play was a quarter of the movement from lock to lock. During the open days, visitors were invited to have their cars tested by the Laboratory's equipment; a common defect found was misaligned headlamps. Of exhibits concerned with vehicles, that which attracted most attention was a short film showing how loss of control can occur when braking and how it can be overcome by using the Maxaret anti-skid device; this releases the pressure in the hydraulic braking system of any wheel of a car as soon as it begins to skid during emergency braking. The car in the film was braked heavily from 65 miles per hour and was manœuvred successfully around obstacles without loss of control. Another striking set of exhibits was a series of toughened glass windscreens which had been caused to crack into the characteristic mosaic by hitting them with a centre punch; a screen made a few years ago which had cracked into a mosaic of forty or more particles per square inch was difficult to see through, but one made to the present British Standard of twenty particles per square inch would provide a fairly clear view of the road ahead.

There were a number of exhibits illustrating the use of statistics (reported by the police and others) in revealing the importance of the various factors—road, vehicle and human—which affect the problem of accidents. For example, these statistics show that one type of accident to which young children are particularly prone could be reduced by fitting an ingenious safety device which consists of a strip of mirror fixed in front of the cab of a battery-driven electric vehicle of the type used for 'milk rounds'. A glance in the mirror before he moves off will enable the driver to detect the presence of a very small child playing on the road immediately in front of his vehicle.

Another group of exhibits was concerned with making roads and air-strips more resistant to skidding. This comprised a car equipped with a 'fifth wheel' for routine tests at normal speeds, a car and 'braking-force' trailer for testing wet airfield runways at speeds up to 100 miles per hour, and the Laboratory's portable 'skid-resistance' tester: this is a simple pendulum device under development for use by highway authorities for detecting slippery roads.

The Laboratory's apparatus for measuring the reflecting power of a road surface was also on show: this constant is needed by illuminating engineers in determining the capacity of the road surface to form the bright patches on which the lighting engineer relies for effective lighting of streets. Pedestrians are mainly seen in silhouette against the bright background of road surface and not by direct illumination.

The traffic exhibit was notable as showing the large amount of data on the way Great Britain's roads are handling traffic. Examples were included of apparatus now available commercially for use by highway authorities for recording the flow and speed of the traffic on their roads. A new feature was the inclusion of teleprinter devices for recording traffic speeds automatically.

A model road was used to illustrate the Laboratory's work in making road signs easier to read; it showed that for signs of the same area and cost, taking the distance at which the British-type sign with 4-in. letters could be read as unity, this distance was half as much again for the Continental 'map'-type sign with 5-in. letters and was doubled for the United States 'list'-type sign with 6-in. letters.

Several of the exhibits were concerned with the development of machinery in road construction; thus in one large hangar type of building covering a number of pits filled with different soils, measurements were in progress of the depth of the compacted layer and the density of compaction achieved by vibrating rollers and vibrating plate devices: this investigation is designed to supplement the information on soil compaction given in the Laboratory's text-book, "Soil Mechanics for Road Engineers". In another hangar, experiments were in progress with a machine which was pulverizing a heavy clay with an action resembling a milling cutter as it moved over it. The problem here was to shred the soil very finely so that it would mix satisfactorily with cement, the resulting 'soil cement' being compacted to give a road base of high bearing power. Another exhibit, dealing with the problem of laying a concrete road free from undulations so that vehicles could ride over it very smoothly, used a working model to demonstrate the advantage of having a long wheel-base to the machine carrying the finishing screed.

In another exhibit samples of road-stones set in cement mortar and forming the tyre of a large wheel were being polished by the rubbing action of the tread of a smooth rubber tyre of another wheel, water and a fine abrasive being pumped on to the tyre. The degree of roughness remaining on the stones after polishing was then assessed in terms of the energy abstracted from a pendulum used to sweep a rubber pad over the samples of wetted stones. Use of this test would ensure that road-stones that polish easily are not used on sites, such as roundabouts on main roads, where it is desirable to maintain a high degree of resistance to skidding for safety in wet weather.

Another group of exhibits gave details of the Laboratory's full-scale road experiments concerned with 'pavement design', that is, the determination of the most economical type and thickness of road construction for use in a particular locality bearing in mind the road-stones and sands available, the bearing power of the subsoils over which the roads are built and the weight and intensity of the traffic to be met with ; here a large-scale plan gave details of the 'step' experiment at Alconbury on road *A*1, where a two-mile stretch consists of sections of different road materials, each laid to a range of thicknesses. Instruments have been installed in each section and these record the pressures and deformations in the road structure and in the subsoil : from these and other studies it should be possible to assess the relative suitability of the various materials involved. In connexion with this type of experiment it is vital to know the weights of the different vehicles using the road ; these are determined by a device which, for the purpose of the exhibition, was shown weighing the fast-moving traffic on the Colnbrook By-pass outside the Harmondsworth Laboratory. The device consists of a steel table, let flush into the road and carrying resistance strain gauges on the four legs : the system causes a spot of light to be deflected across a row of photo-sensitive elements actuating counters, the number of counters triggered off by each vehicle being a measure of the load. Another piece of work being done on this problem of 'pavement design' was exemplified by equipment adjacent to a test-track in the Laboratory grounds at Harmondsworth. Here a heavy vehicle was run over a group of sections of road of different compositions, and piezo-electric gauges in the underlying soil recorded the pressure exerted through each material, thus enabling its ability to spread the traffic loads to be determined.

Several exhibits were concerned with laboratory investigations. Thus a Thoma blood-count slide, modified to act as a micro-viscometer, was being used to determine the viscosity of the bitumen in the extreme surface layers of asphalts. This viscosity increases due to oxidation of the bitumen, but is decreased by the absorption of oil dropped from vehicles. To maintain a high resistance to skidding, an increased viscosity of the bitumen is desirable so that any bitumen in the surface is worn away by traffic so as to expose the sand or other fine aggregate texture.

One problem of immediate practical importance was concerned with determining the best surfacing for the roadway of the new Forth and Severn bridges. Trials on actual sections of the proposed bridge decks have suggested that 1½ in. of mastic asphalt sealed at the edges with rubber/bitumen will hold well to the steel decking and give long service under heavy traffic.

A pictorial display showed something of the work of the Colonial Section.

T. LONSDALE

SCIENCE IN THE USE OF COAL

A CONFERENCE on "Science in the Use of Coal" was convened at the University of Sheffield during April 15–17 by the Institute of Fuel to provide an opportunity for coal scientists to discuss their work with industrialists. Each session began with an authoritative survey of work already published and an appreciation of current industrial problems.

Physics and Chemistry of Coal

In reviewing the properties of British coal seams, A. M. Wandless laid emphasis on the heterogeneity of coal and the great commercial importance of coals of low rank. In the second paper, L. Horton surveyed the chemical constitution of coal, with particular reference to oxidation, functional groups and solvent extraction. I. G. C. Dryden extended this discussion, referring, *inter alia*, to statistical structural analysis and physical structure. These valuable summaries not only provided a foundation for the subsequent proceedings, but also focused attention on what remains to be done and the most likely fields of application. For example, Dryden said that carbonization offers the most immediate application for coal science, while Wandless made clear that further work applicable to the use of small coal of low rank and on sulphur and other mineral constituents is particularly necessary.

During the session it became clear that there is now available sufficient information about the aromatic skeleton in coal and the nature of non-aromatic and oxygen groups to limit closely the possible views on the structure of coal. P. B. Hirsch interpreted the X-ray evidence for vitrains containing up to 90 per cent carbon in terms of ordered layers containing a few condensed aromatic rings, the layers being cross-linked to form larger units. This view conforms with the chemical evidence. P. H. Given and M. E. Peover provided evidence from controlled potential electrolysis for the presence of carbonyl groups conjugated with the ring system, previously suggested from consideration of the behaviour of the 1,600-cm.$^{-1}$ band in infra-red spectra. Attempts to reduce the aromatic systems led P. H. Given, V. Lupton and M. E. Peover to suggest that this process is resisted in coals of low rank owing to a high degree of cross-linkage. J. K. Brown *et al.* demonstrated by purely chemical means the presence of aliphatic groups, showing also that halogenation and nitration may prove efficient in introducing desired functional groups into coals. Photochemical studies by R. Bent and J. K. Brown showed that solid coals are not photo-oxidized readily; but oxidation occurs when solutions of extracts of coal are irradiated by means of a mercury arc; similarly, chlorination of fine coal suspended in carbon tetrachloride also occurs. D. E. G. Austen and D. J. E. Ingram reported on the effect of carbonization and chemical treatment on the concentration of free radicals, concluding that the unpaired electrons are little influenced by the particular edge-groups present, but are closely associated with the aromatic skeleton.

P. J. Farenden and E. Pritchard reported a laboratory process giving good yields of highly fluorinated oils, without tar, in a single-stage reaction between coal of low rank at moderate temperatures and chlorine trifluoride. This empirical development may well find direct application in the fluorocarbon market.

N. Desai and S. J. Gregg showed that only when a compact swells as a result of sorption of vapours is it mechanically weakened thereby. From his studies of the sorption of methane by anthracite, A. S. Joy suggested for the latter a physical structure resembling that of a slightly elastic zeolite system.

These nine papers, since they represented current work only, did not cover the whole of present-day coal science; and physical structure had been covered at other recent conferences. It is a sign of the advances that have been made that the papers were followed by a lively and informed discussion, from which it was evident that the next few years will see a rapid clarification of what can, and what cannot, be done with coal.

Preparation and Breakage of Coal

In the second session, V. Fidleris and R. L. Whitmore described an electromagnetic method for measuring the falling speed of small foreign particles through stable suspensions, while G. F. Eveson and J. E. Gresham reported on the initial stages of a study of the factors governing the settling of floccules. The gap between these papers and the practical problems to which W. R. Chapman directed attention in his introductory survey was large, showing that the scientist's contribution to coal washing (in contrast to the maturity of fundamental studies) is only beginning. However, P. J. Beckett, A. D. Cummings and R. L. Whitmore showed the practical benefits that can accrue: their account of the disintegration of shales in water suggests that control of the pH of washery water might usefully reduce the slaking of shales. J. C. Macrae's data on the bulk density of crushed coal in relation to handling are applicable in carbonization, where charges of controlled bulk density are required.

The mathematics of breakage of coal is well advanced. I. Evans proposed a modification of Gaudin's law of size distribution in which account is taken of the dependence upon size of the probability of survival of the particles. T. G. Callcott extended the matrix representation of breakage processes to cover a second characteristic (such as ash content), showing that the selectivity or otherwise of a breakage process can be tested only by careful experiments. J. E. Ellis, W. D. Ray and J. Venables reported the experimental determination of a breakage matrix, which indicated the occurrence of interaction between particles differing in size. These papers provide a valuable tool for practical studies and show why much *ad hoc* work in the past has been inconclusive.

Carbonization of Coal

The ten papers that followed J. E. Davis's admirably compact survey of current knowledge gave ample testimony that science has made, and is now making, substantial contributions to this traditional use of coal. G. W. Fenton and A. H. V. Smith showed how petrological analysis assists in the selection of coals. J. J. Kipling and R. B. Wilson carbonized synthetic polymers and concluded that the properties of the carbon produced depend on the degree of cross-linking present in the original material or developed during its primary decomposition. Use of infra-red spectroscopy by A. L. Roberts, J. H. Towler and B. H. Holland in the analysis of carbonization gases showed the presence of a wide range of gaseous hydrocarbons and sulphur compounds, suggesting that these gases may be a potentially useful source of chemicals. Studying the chemical nature of coal-tar pitch, L. J. Wood and W. G. Wilman concluded that the largest molecules have branched chains of fused benzene and heterocyclic rings.

P. C. Finlayson and J. C. Macrae had made a preliminary study of the fluidity of a coal in the initial stages of thermal softening and suggested the presence of disk-shaped units in a solid/liquid system.

Another group of papers covered the cokes and chars produced by carbonization. J. G. O'Connor, M. W. Thring, C. Hulse and M. G. Perry showed that high volatile coal could be partially carbonized by a high rate of convective heating, lasting only one hour, to give a reactive and smokeless char, strong enough for the domestic market; the laboratory work was supported by studies at the pre-pilot stage and calculations for plant design. J. Owen described plant studies on the production of char in a fluidized bed. If these two processes should prove economical on further development, they could contribute to the availability of reactive smokeless fuels.

On the nature of cokes, A. D. Dainton and J. W. Phillips showed that cracking of briquettes is probably due to differential shrinking rather than evolution of gas and could be reduced by keeping the rate of heating below a critical value. M. S. Iyengar and R. S. Ghosh indicated that the strength of lignite briquettes is influenced by the presence of polar molecules and is increased by replacing much of the moisture by other polar compounds such as methyl alcohol or formic acid. A straightforward examination of the resistance of coke to breakage on impact led R. A. Mott to the important statement that it would be advantageous to use a smaller size of coke than is customary in blast furnaces.

Combustion and Gasification

In their introductory survey, R. H. Essenhigh and M. G. Perry directed attention to the relative importance of physical processes of diffusion and of rates of chemical reaction. This question is not fully resolved. D. B. Spalding described an ingenious model technique for studying the combustion of pulverized fuel. Then J. H. Burgoyne and V. D. Long reported some measurements of the burning (flame) velocity of suspensions of powdered coal in air, indicating, *inter alia*, a reduction in velocity when sodium chloride was added. R. H. Essenhigh and M. W. Thring measured the burning time of single particles of coal, relating it to the particle size and rank of the coal.

G. Underwood and M. W. Thring showed that over the temperature-range 650–850° C., coal smoke burns more readily than methane and unsaturated hydrocarbons. J. W. Hardcastle and M. W. Thring described apparatus for measuring luminous radiation from the flame over an over-feed coal bed and related it to the rate of feed of the coal and the percentage of secondary air. P. H. Crumley and W. McCamley discussed the behaviour of chlorine in coal during combustion, which is important in boiler firing, and suggested that the extent of vaporization of alkali is best related to the ratio of chlorine to ash-content.

The urgent need for further work was emphasized in the discussion, particularly in regard to the combustion of pulverized fuel.

Reactivity of Cokes and Chars

H. E. Blayden's survey of the kinetics of the reactivity of cokes and chars was supplemented by F. A. Burden's comparison of different methods of measurement. From analyses of the gases produced from pre-dried briquettes when burnt in air at a series of constant temperatures, D. R. Williams and J. A. Pudifoot proposed an index of chemical reactivity; comparisons with performance on open grates confirmed that (owing to the formation of surface oxide) the rate of loss of weight is not a sufficient measure of relative reactivity; but values of chemical reactivity at zero and at 1 per cent burn-off appeared to be well correlated with various practical characteristics of the fuels. L. J. Jolley and J. E. Stantan found that their measurements of reaction-rates of cokes with steam at 900° C. and with air at 475° C. were not correlated with specific surface areas of the cokes, suggesting the relevance of other factors such as ash constituents. Approaching the problem in a different way, F. D. Moles determined the minimum rate of burning at which a practicable bed of coke can be kept alight.

These papers and the discussion showed that there is still much to be learned about the physical and chemical factors determining the reactivity of coke, especially in regard to the relative importance of these, and other factors, in practice.

The discussions in each session added materially to the content of the papers. This is a sign that the number of established facts about coal now provides the scientist with a sure foundation for his work and will progressively simplify further work, although perhaps with coals of low rank new problems will arise. There is little doubt that the minerals associated with coal—only occasionally referred to at this conference—require much more consideration.

In every use of coal a diversity of mechanisms operates and the inter-relation between these is not yet on a quantitative basis. However, enough has been done to point the way and to show the potential benefit. When the investigations have proceeded further with a wide enough range of coals and associated minerals, the technologist also will have a sure foundation for his work. To achieve this end, the skills of every type of scientist and engineer must be blended. A philosophy of this most difficult field of industrial research emerged in some of the interchanges with industrialists, although the serious problem of communication, namely, the need for common language, was also evident.

The proceedings of the conference are to be published later this year. R. L. Brown

THE EUROPEAN SEISMOLOGICAL COMMISSION

THE fourth general assembly of the European Seismological Commission was held in Utrecht during April 8–12, by invitation of the University and the Royal Netherlands Meteorological Institute, and with the support of Unesco.

The plenary meetings were held in the University building. The assembly was exceptionally well attended, there being fifty-nine representatives from twenty-four European and circum-Mediterranean countries in addition to several occasional visitors. The main discussions centred on the Earth's crust; seismological apparatus; the European earthquake catalogue; dynamical interpretation of earthquakes; and canalized waves in Europe.

After the session had been opened by the president, Prof. P. Caloi (Rome), the delegates were welcomed by Dr. C. J. Warners, director of the Royal Netherlands Meteorological Institute, on behalf of the Minister of Transport and Waterways, and by Mr. C. J. A. de Ranitz, burgomaster of Utrecht.

The outer layers of the Earth above the Mohorovičić discontinuity (usually called the crust) are now being studied extensively by means of great explosions. Such explosions have already been made in the French Alps during August and September 1956, in Germany and in the U.S.S.R. These investigations have shown that the Mohorovičić discontinuity is depressed under great mountains. Further experiments are being planned.

The catalogue of European earthquakes, to include instrumentally determined epicentres, depth of foci and initial times, as well as magnitude and macroseismic data, is being compiled, and a seismic map of Europe is being drawn. A general discussion was held on the definition and representation of seismicity, and on the determination of the 'magnitude' of an earthquake from macroseismic (non-instrumental) observations. It will be remembered that the 'magnitude' of an earthquake is now defined precisely in terms of instrumental data, and that this is different from the 'intensity' of the earthquake determined macroseismically. Recent earthquakes in many parts of Europe were also discussed as additions to the catalogue. It is envisaged, considering the progress already made with the seismic map of Europe, that the time will soon come when it will be fruitful for seismologists and geologists to meet again to discuss seismotectonic problems, and to attempt the construction of a seismotectonic map of Europe.

The construction of instruments for the better registration of earthquakes in general and for the recording of particular data in connexion with problems of the theory of elastic waves is being continued. A fruitful method has been, first, to construct a shaking table to simulate the earth-movements, and then to determine the response of the seismograph to the known movements of the table. A great deal of ingenuity has gone into the construction of both tables and seismographs at Zurich, Stuttgart and elsewhere, and reports on the progress of the work, which is continuing, were given. For the general registration of earthquakes modern requirements are at least three components (north–south, east–west and vertical (Z)), and it was emphasized that for the study of particular waves it is preferable to have all three components giving identical response (that is to say, with the same frequency characteristics).

It would be invidious to attempt to assess the importance of the papers presented at the meetings, but perhaps summaries of two may be given.

The first, by Dr. R. Teisseyre, of the Geophysical Institute of the Polish Academy of Sciences, described the mechanism of earthquakes in terms of dislocation theory. The basic assumptions are the existence of the non-hydrostatic part of the stresses in the medium (Py 2) and the supposed distribution of the inhomogeneities (in the largest sense). This distribution includes some plane and its neighbourhood as the plane of active dislocation processes (slip plane, $y = 0$). It has been shown by Dr. R. Teisseyre and Sophia Droste that the inhomogeneities can be represented by the loop dislocations in the presence of the field Py 2. The loop dislocations increase under the influence of the field Py 2, and by interaction between themselves (synthesis of loops). The slip area increases. Finally, when the dislocation reaches the Earth's surface its energy is discharged. The calculated energy of discharge is in good agreement with observational data.

In the second paper, Dr. H. Berckhemer (Stuttgart) discussed the influence of the movement at the focus of an earthquake on the seismic wave spectrum. Dr. Berckhemer first stated his method of separating the influence of happenings at the focus from the influences of the wave-path and the seismograph on the wave spectrum. It appears that when the magnitude of an earthquake increases, the long-period wave spectrum is stimulated. Dr. Berckhemer explained this by theory and observation as being caused by extensive fault-breaks at the focus. His thesis is that it is possible to establish a connexion between the spread of the broken surface and the earthquake magnitude. This would make an important basis for the calculation of earthquake energy.

General impressions of the conference were, first, the intense interest of all present and the cut and thrust of very pointed discussion on all topics raised; secondly, the shift of emphasis on problems being tackled—for example, the present interest in very great explosions for seismological purposes and the return of 'La Géologie Sismologique' as introduced by the late Comte de Montessus de Ballore—and thirdly, the tendency to specialization within seismology.

It is expected that a second series of great explosions will take place during the summer of 1958 in the French Alps, and also that an explosion of 30–40 tons of explosive will be arranged to take place at a depth of some 300 metres in Belgium in September 1958. The elastic waves from these explosions will be recorded on seismograms and further knowledge obtained of the deeper structure of the Earth's crust. It is recommended that seismological stations obtain as soon as possible homogeneous sets of apparatus (recording three components having the same frequency characteristics) so as to be able to tackle seismological problems the more readily by direct comparison of the three components of vibration.

It is anticipated that the next meeting of the Commission will be held in Alicante during October 1959, when it is hoped that a symposium in collaboration with geologists will be held on seismotectonic problems, and another on the dynamical study of surface-wave problems.

The following were elected to office in the European Seismological Commission: *President*, Prof. P. Caloi (Rome); *Vice-Presidents*, Dr. J. Bonelli-Rubio (Madrid) and Prof. E. T. Savarensky (Moscow); *Secretary*, Mr. E. Peterschmitt (Strasbourg).

E. TILLOTSON

CLASSIFICATION OF BRACKISH AND INLAND SALINE WATERS

AT the International Congress of Limnology in Helsinki in August 1956, problems of brackish water were discussed and, at the suggestion of Prof. S. Segerstråle, it was planned that a small group of specialists should be invited to attend a conference with the view of recommending a scheme of classification of brackish and inland saline waters which could be generally acceptable.

This conference was held during April 8–14 of this year at Venice under the joint auspices of the International Association of Limnology and the International Union of Biological Sciences. The place of meeting was the Centro di Studi Talassografici, the director of which, Prof. U. D'Ancona, is also president of the International Association. Papers were read by S. Segerstråle (Finland), A. Remane (Germany), B. Havinga (Holland), M. Băcescu (Roumania—*in absentia*), G. Petit and D. Schachter (France), U. D'Ancona (Italy), J. W. Hedgpeth (United States), L. C. Beadle (Uganda), H. Caspers (Germany), D. J. Rochford (Australia—*in absentia*), W. Schmitz (Germany) and E. Dahl (Sweden). The conference was also attended by J. Dill, M. Girard and P. Job (Food and Agriculture Organization, Rome), by T. T. Macan (secretary of the International Association of Limnology), and by some Italian biologists (A. Marcello, B. Battaglia, A. Vatova and A. Giordani Soika).

The papers were concerned with the history of the subject, and with the ecology of brackish waters in the Baltic, Elbe estuary, Black Sea, the lagoons of southern France and the Adriatic, some Australian estuaries and of intertidal zones of the Scandinavian coasts. Inland saline waters in the southern United States of America, Germany and in North and East Africa were also discussed, and the physiological mechanisms for adaptation to brackish and saline waters were reviewed.

The conference was very successful as a stimulating exchange of views and information on a subject, accounts of which have been very diffusely published and are thus difficult to collate.

At the final session a basic scheme was proposed for the classification of brackish waters which, in the opinion of the conference, would provide a useful framework of general application. It is based on zones of salinity of known biological significance and owes much to the earlier classifications of Redeke and Välikangas. Into this scheme more detailed sub-categories could be fitted to suit local conditions.

The proposed scheme is as follows :

Zone	Salinity-range (°/₀₀)
Hyperhaline	$> \sim 40$
Euhaline	~ 40 to ~ 30
Mixohaline	$(\sim 40) \sim 30$ to $\sim 0{\cdot}5$
Mixoeuhaline	$> \sim 30$ but less than adjacent euhaline sea
(Mixo)polyhaline	~ 30 to ~ 18
(Mixo)mesohaline	~ 18 to ~ 5
(Mixo)oligohaline	~ 5 to $\sim 0{\cdot}5$
Limnetic (freshwater)	$< \sim 0{\cdot}5$

For inland saline waters, it was agreed that no useful purpose could be served at present in devising a scheme of classification based on salinity zones. They are extremely variable in composition and several factors other than salinity are of great ecological significance. Moreover, our knowledge of them is as yet comparatively slight.

Venice is obviously a very suitable as well as delightful environment for a conference on this subject and, in spite of most unfavourable weather, excursions were made in and around the Venetian Lagoon. Here the technique of fish culture known as *vallicoltura* has been practised for many centuries and it involves some interesting problems in brackish water biology.

Through the generosity and hospitality of the Mayor of Venice, of the Venetian Tourist Association, of the Consorzio Vallicoltori, of Prof. D'Ancona and Prof. Alessandro Marcello, the members of the conference were able to enjoy much more than the biology of the Lagoon and were permitted to see many things of historic and artistic interest under expert guidance.

The proceedings of the conference will be published in Venice by the Centro di Studi Talassografici.

L. C. BEADLE

THE CARNEGIE TRUST

THE fifty-sixth annual report* of the Carnegie Trust for the Universities of Scotland, covering the year 1956–57, includes the report of the Executive Committee with a summary of grants for the ninth quinquennium, October 1, 1952–September 30, 1957, the abstract of accounts for the year ended September 30, 1957, and the report upon the work of investigators, with lists of publications by scholars and recipients of grants and assisted papers. No new research scheme was introduced during the year, but those in operation have yielded satisfactory results. The block grants to universities to assist staff whose research involves travel are regarded as invaluable, and also the scheme enabling ten members of the staffs of universities to study abroad for up to twelve months, under which, in 1956–57, a geologist worked in Greenland, an archæologist in Asia Minor, a philologist in Ethiopia, a physiologist, zoologist, philosopher and surgeon in America, a biochemist and botanist in Canada and a historian in France. Assistance was given in the publication of seven manuscripts submitted by Scottish graduates or members of the staffs of Scottish universities. No fellowships were awarded, but, besides four senior scholarships, 36 scholarships were renewed and 23 awarded in June 1957. The Executive Committee is concerned to remove anomalies which have been created between Department of Scientific and Industrial Research grants and those obtainable from the Scottish Education Department on one hand and Carnegie Scholarships on the other. Repayments by former beneficiaries totalled £2,884.

The report upon the work of investigators under the research scheme during the year refers particularly to J. Y. Thomson's continued work on the numerical evaluation of the boundary layer flow past a flat plate placed lengthwise to the stream ; A. V. Gold on the de Haas–van Alphen effect in conductors at high magnetic fields ; Dennis Mackay on the interdiffusion of the ions Na^+, H^+ and Cl^-, and also water across an ion exchange membrane ; Donald Mackay on the decomposition of the peroxides of the organic acids ; and Iain M. T. Davidson on the dissociation of dibenzyl, in which he determined the kinetics of the decomposition and the bond-strength of the central C—C bond. A. E. Scott in his study of the acid-base and thermal racemization of the ketols has shown that the activation energy of the former is approximately half that of the latter. I. D. R. Stevens continued work on the addition of dinitrogen tetroxide and nitryl chloride to substituted olefines and on the effects of substituents adjacent to the double bond on *cis-* and *trans-* additions, while J. F. McKellar has identified the CHO, CH and OH radicals in the flash photolysis of acetaldehyde and formaldehyde both in absence and in presence of oxygen and is now studying the kinetics of their formation.

R. Logan has studied the influence of cytoplasm on the multiplication of ribonucleic and deoxyribonucleic acids in nuclear processes, using compounds labelled with carbon-14, and also the action of ultraviolet light and X-rays, using nuclei from normal and regenerating rat-liver cells and from calf thymus. M. Los's attempts to find a general synthetic route for the β-quinindines and the β-pyrindines failed, but gave some interesting new compounds. Janet Buchanan's work on the herbarium material on the genus *Luzula* in Kew and Edinburgh is nearing completion, and Isobel C. Gardner's work on nitrogen fixation in root nodules of non-leguminous plants has shown that the American *Myrica cerifora* can be inoculated from *M. gale* and that nitrogen fixation is carried on by nodules so induced. G. K. Wallace's work on visual responses in locusts is a useful contribution to our knowledge of locust behaviour. Beatrice M. Blance's work on the origin and development of the Iberian Bronze Age and Elizabeth Burley's study on the archæological evidence for Scottish–Irish connexions in the Dark Ages are specially commended.

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* Carnegie Fund for the Universities of Scotland. Fifty-sixth Annual Report (for the year 1956–57) submitted by the Executive Committee to the Trustees on 24th February, 1958. Pp. iv+73. (Edinburgh : Carnegie Trust for the Universities of Scotland, 1958.)

VISUAL ORGANIZATION

By Dr. W. K. TAYLOR

Department of Anatomy, University College, London

IN the functional theory of the mammalian retina which I proposed in 1955[1], the discharge frequency of the ganglion cells in response to distribution of light intensity on the retina was represented by an equation of the form:

$$f(m,n) = c_1\, d(m,n) - c_2 \sum_R f(p,q) \qquad (1)$$

This equation was based on the physiological experiments of Kuffler[2] in which ganglion cells in the cat retina lying beneath a small spot of light were found to discharge nerve impulses at an increased rate in response to the illumination, whereas surrounding ganglion cells within a small distance of the spot were silenced.

In equation (1) the spread of this inhibitory influence is denoted by a radius R and the retina is assumed to be divided into a matrix of small squares. Within any small square situated at the junction of row m and column n the average frequency of ganglion cell discharge is denoted by $f(m,n)$. The constant c_1 represents the potential increase in ganglion cell frequency that would be caused by unit increase in the depolarization of the cell in the absence of inhibition, that is when c_2 is zero. The depolarization or driving function $d(m,n)$ is assumed to be the result, through photochemical action, of the average light intensity over square m,n, and it is suggested that a reduced and decaying value of this function also represents the driving signal of the ganglion cell during after-image phenomena. The constant c_2 represents the potential decrease in ganglion cell frequency that may be caused by unit change in the summated inhibition or hyperpolarization associated with the discharge of ganglion cells within a radius R of the square m,n.

Graham and Granit suggested in 1931[3] that the lateral inhibitory signals could be carried by amacrine cells, but there is also a possibility that the inhibition may be transmitted between the rods and cones through horizontal cells. The theory, as formulated by equation (1), predicts responses to visual stimulus patterns that can be correlated with the visual phenomena of contour formation and simultaneous brightness contrast. There is, however, no component of output that can be related to the phenomenal movements in response to certain types of stationary stimulus patterns reported by observers in the experiments conducted by Erb and Dallenbach[4] and MacKay[5]. The earlier experimenters showed to a number of observers the Luckiesh–Moss[6] stimulus pattern (Fig. 1*a*), which consists of rows of equally spaced white lines on a black background. After a 1-min. presentation with adjacent white lines subtending a visual angle of 14·5′ all the observers reported having seen a "streaming movement" like "the drift of very fine snow" at right angles to the lines and proceeding in one direction or the other at various speeds from a slow drift to rapid streaming. The origin and explanation of this phenomenon are still unknown and the object of the present article is to suggest an explanation in terms of an extended form of my original theory[1] with two additional physiological features. These features are adaptation and post-inhibitory rebound, and since they take effect only after a period of fixation on a stimulus pattern their effects were neglected in the original

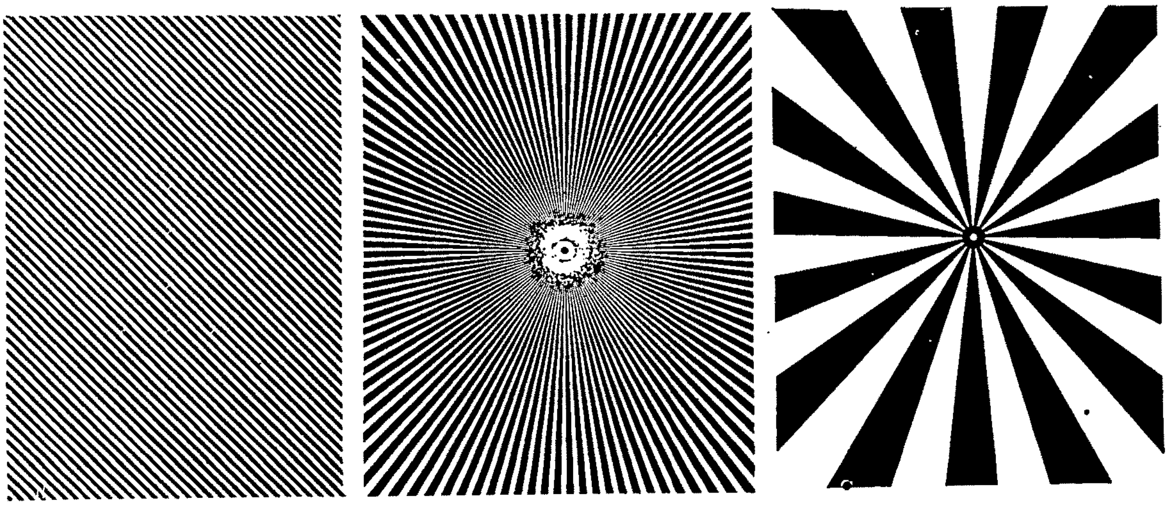
(*a*) (*b*) (*c*)

Fig.

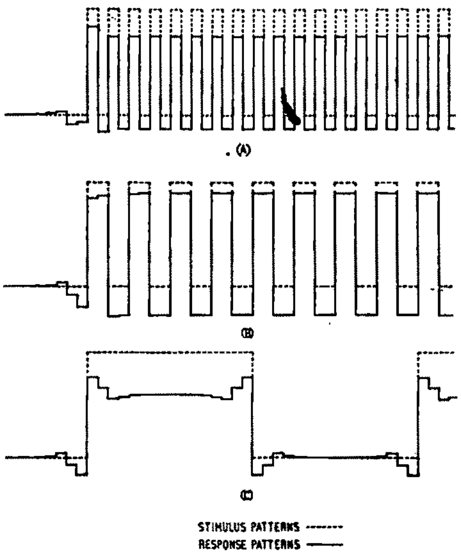

Fig. 2

theory, which was only intended to cover the initial response. The effects of eye movements during fixation are neglected in this theory since they are known to be small compared with the visual angles subtended by the relevant details of the patterns considered.

Adaptation and post-inhibitory rebound may be defined respectively as the decrease in firing frequency of a single excited ganglion cell with time when the stimulus is constant, and the burst of impulses generated by an inhibited cell when the inhibition is removed. Both effects can be seen in Kuffler's Fig. 8 (ref. 2).

The ganglion-cell firing pattern in response to the Luckiesh–Moss type of stimulus pattern predicted by the original theory is only similar in shape to the stimulus pattern if the line separation is of the same order of magnitude as, or less than, $2R$ when both are measured in terms of visual angle. This can be seen from Figs. 2*A*, *B* and *C*, in which the full lines respectively show cross-sections of the predicted firing pattern for parallel line stimulus patterns in which adjacent white lines, equal in width to the black lines, subtend visual angles of R, $2R$ and $16R$ degrees. The dash lines show the corresponding stimulus patterns to an arbitrary scale and also the predicted ganglion-cell firing patterns in the absence of lateral inhibition, that is when c_2 in equation (1) is zero. When the line spacing is large compared with $2R$ the theory predicts higher firing rates at the edges of the white lines than at their centres; in other words, the formation of contours or edges as shown in Fig. 2*C*. By investigating a complete series of patterns with different line spacings it is possible to show that the maximum inhibition of the neurones corresponding to the dark lines of the patterns occurs when the distance between the centres of adjacent white lines is equal to $2R$ as in Fig. 2*B*. The maximum inhibitory effect can thus be said to occur when the line pattern is matched in size to the inhibitory spread parameter of the theoretical model.

The parts played by adaptation and post-inhibitory rebound in the extended theory will now be considered by assuming that the stimulus pattern of Fig. 2*B* is fixated at time $t = 0$ on a part of the retina for which $2R$ is approximately equal to the separation of the white lines in the image, as required for matching. During the first fraction of a second the predicted response will be as shown in Fig. 2*B*, the activity in areas under the white lines inhibiting the activity under the black lines to a point well below the resting level corresponding to black except for the edge effect on the left. According to the extended theory, the neurones beneath the white lines begin to adapt and in doing so their inhibitory influence over the neurones beneath the black lines will be reduced until the latter eventually fire at higher rates according to the post-inhibitory rebound effect. In doing so they will inhibit the adapting neurones, thereby accelerating the reduction of their firing frequencies. If the magnitudes of these effects are sufficient, there is clearly a possibility that the rebounding neurones may become more active than the adapting neurones and it is suggested that this does in fact happen to a randomly distributed proportion of neurones during the apparent streaming-movement phenomena. A much larger rebound can be expected if the stimulus pattern is suddenly replaced by a plain surface since the adapting neurones will then lose the powerful drive by the white lines, this being replaced by the smaller after-discharge of the receptors.

In Kuffler's experiment the stimuli were spots of light for which equation 1 predicts a small inhibitory effect. With the parallel lines of Fig. 2*B* the predicted inhibition is much greater, and it is suggested that the rebound produced by this pattern can be large enough to cause appreciable inhibition of a proportion of neurones under the white lines or the neurones which were under the white lines if the pattern has been removed. The rebound is known to be transient, however, and when it decays the neurones under the white lines that have been transiently inhibited should tend to rebound and hence to restore the original pattern of activity. If the rebounds are sufficiently large the complete cycle may be repeated an unlimited number of times if the pattern is still present or a finite number of times at decreasing amplitude if the pattern is removed. The repeated cycles, assuming that they can occur, might be called rebound oscillations.

An optic nerve discharge pattern corresponding to a partial oscillatory after discharge following a period of fixation on the matched pattern could be expected to resemble the discharge pattern actually produced by interchanging the positions of the black and white lines of the stimulus pattern, except for the blurring of the former due to the random distribution of the oscillating neurones. It is suggested that in either case the observer can interpret the discharge pattern as a continuous movement in either direction at right angles to the lines of the inducing pattern. According to this theory the apparent movements can be regarded as analogous to the special case of the apparent movements created by projecting a cinematograph film of a set of lines such as a white fence or the spokes of a carriage wheel in which the change of image position between successive frames is equal to half the spacing of the lines. It is then impossible to decide for certain which way the lines are moving and the fence or carriage wheel may appear to move in either direction.

The extended theory leads to the following predictions. The apparent movements should increase in intensity as the contrast between the illumination of the white and black lines increases and as the width and separation of the lines are adjusted to match the inhibitory spread of the area of retina used for viewing the lines. If the white lines are very narrow relative to the black their inhibitory effect will be small, and if they are too wide the inhibitory effect will be small. In either case the oscillation should be absent or short-lived and of low intensity. For a given ratio of widths the apparent movements would be most obvious when the line separation is of the same order as the width of the inhibitory field surrounding each element of retina.

Beitel's[7] curves for two-spot interaction indicate that the spread ranges from approximately 17′ visual angle in the central region to more than 2° in the periphery. It is therefore interesting to observe that the radial-lines stimulus pattern employed by MacKay[5] (Fig. 1*b*) was viewed at a distance of 1 metre and that at this distance the visual angle subtended by the centres of adjacent white lines at a radius of half the average distance from the centre to the edge of the pattern is also approximately 17′. It is obvious that with very small line spacing the pattern will not be resolved, but the theory predicts that the movements should also disappear for spacings that are large compared with 17′ in the foveal region or 2° in the periphery. With such wide lines the inhibition only extends a relatively short distance into the black region from the white boundary as shown in Fig. 2*C*, and the rebound can then only give rise to border or edge oscillations on the black–white boundaries. There is no apparent reason why the corresponding neural discharge pattern should give an illusion of continuous streaming movement since there is no tendency for the central parts of the black lines to give rebound impulses.

This prediction has been confirmed by experiments in which the stimulus pattern shown in Fig. 1*c* was employed. This pattern is based on Fig. 1*b* but the separation of the lines at any given radius is increased by a factor of eight to correspond with the eightfold increase in separation from Fig. 2*B* to Fig. 2*C*. In the experiments observers looked at enlargements of the patterns shown in Figs. 1*b* and 1*c* for 1 min. on different occasions but with the same illumination. Out of 30 observers tested, none reported having seen the circular streaming movement while viewing a 30 cm. × 40 cm. enlargement of Fig. 1*c* at 1 m., but all reported the effect with a similar presentation of the pattern employed by MacKay. The interpretation of this result in terms of the theory is that the inhibition within retinal areas beneath the central portions of the black areas of the image produced by Fig. 1*c* is insufficient to cause any appreciable rebound and that the illusion of a continuous smooth streaming movement is thereby lost.

In addition to the foregoing predictions concerning the magnitude of the movement phenomena the extended theory also predicts that the apparent velocity of the streaming movement with parallel line patterns or the angular velocity with radial line patterns, measured in lines crossed per second, should be equal to the frequency of the rebound oscillations measured in cycles per second. It is difficult to see how this could be tested experimentally since the nerve impulses generated by a single ganglion cell would have to be recorded and compared with the observer's estimate of the streaming velocity. It is possible to predict an upper bound to the velocity, however, since the highest frequency of oscillation could only be attained with one nerve impulse per cycle. The duration of an impulse is approximately one millisecond, and if the theory is correct it should be impossible to have an impression of a velocity in excess of 500 lines/sec. A velocity of 10 lines/sec. would seem more reasonable from Kuffler's recordings while my estimate of the velocity is approximately 30 lines/sec.

MacKay has suggested[5] that the moving visual images might occur in response to informational redundancy or regularity in the visual field. The present theory, however, predicts that although regularity is a necessary condition it is by no means sufficient, and that only a very restricted range of sizes and shapes of regular pattern should produce the phenomena. An example of a highly regular visual field that shows no sign of inducing the phenomena is a plain surface of any intensity for which the same signal is repeated at all points and which is therefore extremely rich in redundant information. More complex fields having the same degree of regularity may or may not give rise to apparent movements depending on the visual angle subtended by the elements. If, in particular, a circle is divided into $2n$ equal sectors which are alternately black and white ($n = 120$ for MacKay's pattern, Fig. 1*b*), the patterns so formed could be said to be equally regular irrespective of the value of the integer n. Since the streaming movement does not occur for plain surfaces it is evidence that for a fixed viewing distance it must disappear as n tends to infinity or zero. It appears when $n = 120$, but not when $n = 15$, and it is therefore apparent that the actual dimensions of the stimulus pattern image on the retina as well as the regularity of the pattern is an important factor, as predicted by the theory. The general criteria for the appearance of the streaming novement appear to be that there should be a number of equidistant lines separated by a visual angle that matches the inhibitory spread in the area of retina on which the lines are projected. It should be noted that, so far as a small element of area is concerned, radial, concentric or wavy lines that only change direction slightly within the area can be approximated by parallel lines within the area for the purpose of evaluating equation 1. The theory predicts oscillations and apparent movements for any pattern that gives an image of a sufficiently large number of roughly equidistant light and dark alternating lines of suitable separation and width on the retina.

There is, of course, the possibility that interaction of the type described by equation 1 may occur at higher levels of the pathway, and in particular the stellate cells of the visual cortex described by Sholl[8] may transmit inhibition between the pyramidal cells, just as the Renshaw interneurones of the spinal cord transmit inhibitory signals between motoneurones. Unfortunately, it is difficult to imagine an experiment that would locate the origin of the movement phenomena, but the available evidence at the moment appears to be in favour of the retina as a possible source, if not the only source.

The helpful suggestions made by Prof. J. Z. Young and Dr. J. A. B. Gray are gratefully acknowledged. The work was supported by research grants from the Nuffield Foundation.

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ACTIVATION OF HORMONAL SECRETIONS

Precorticotropin

In a number of communications from this laboratory[1–4], evidence has been published for the presence in certain anterior pituitary preparations of material which is ineffective in rapidly reducing the ascorbic acid content of the adrenal gland of the hypophysectomized rat when administered intravenously[5] (Sayers test), but which can elicit an increase in weight of the adrenal glands of the hypophysectomized rat when injected intraperitoneally over a period of some days (adrenal weight test). Other investigators have also found discrepancies between the results of the Sayers test and the adrenal weight test with different pituitary preparations (see Stack-Dunne and Young[6] for a review of these publications). Although the administration of growth hormone can bring about an increase in the weight of the adrenal glands of the hypophysectomized rat largely through stimulation of mitotic activity[7–11], it is most unlikely that growth hormone is the only substance in the crude pituitary extracts we have used[1,4] responsible for the increase in weight of the adrenals. We have used[1–4], among other pituitary preparations, a crude sterile alkaline extract of ox anterior pituitary prepared by a method described by Young[12] which contains little or no corticotropin as measured by the Sayers assay, but which is active in increasing adrenal weight. The virtual or complete absence from this crude ox pituitary extract of activity in the Sayers test was puzzling[13], particularly since fresh ox anterior pituitary tissue contains much corticotropin extractable by acid-acetone.

We have now found that our crude sterile alkaline extract of ox anterior pituitary (*FGS*), which is devoid of activity detectable in the Sayers test, acquires this activity after extraction with acid-acetone according to the method of Lyons[14]. Moreover, this activity rapidly appears in the extract if its *p*H is brought to the acid side, maximum activity being attained at *p*H 3 (Table 1 and Fig. 1). Activity is obtained if the *p*H of the injected material is left at *p*H 3 or brought back to *p*H 8 immediately before injection, and whether or not any precipitate formed in adjusting the *p*H to 3 is spun off before the biological test is carried out. Furthermore, we have found that activity in the Sayers test also appears when the crude extract is treated with urea (3–8 *M*). It is convenient to refer to the material which gives rise to activity in the Sayers test as the result of these mild treatments as 'precorticotropin'.

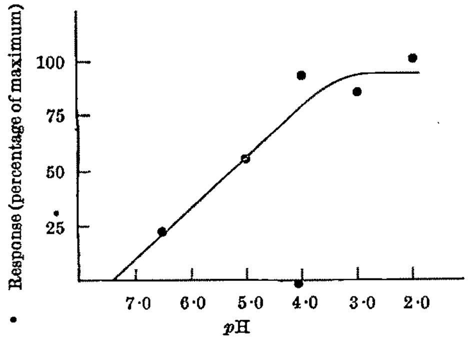

Fig. 1. Effect on the activity of *FGS* in the Sayers test of lowering the *p*H for approximately 30 min.

Table 1. ACTIVITY OF A CRUDE ALKALINE OX ANTERIOR PITUITARY EXTRACT (*FGS*) IN THE SAYERS TEST

Change in adrenal ascorbic acid content (μgm./100 mgm. adrenal) with:		
Untreated extract	Extract adjusted to *p*H 3	Extract treated with urea
+ 8 ± 5 (23)	– 55 ± 4 (31)	– 83 ± 8 (24)

0·25 ml. of extract injected/100 gm. body weight. The number of animals used in each test is given in parentheses

Table 2. ADRENAL WEIGHT-INCREASING ACTIVITY OF CRUDE ALKALINE OX PITUITARY EXTRACT (*FGS*) BEFORE AND AFTER ADJUSTMENT OF THE *p*H TO 3·0

Weight of the two adrenal glands of hypophysectomized rats:		
Control values (mgm.)	Values (mgm.) after 3 days treatment with:	
	FGS untreated	*FGS* brought to *p*H 3·0
10·1 ± 0·5 (5)	16·6 ± 1·0 (4)	13·5 ± 1·0 (5)

0·25 ml./100 gm. body weight of extract injected daily for three days. The number of animals in each group is given in parentheses

When the *p*H of the crude extract (*FGS*) is brought to 3 by the addition of dilute hydrochloric acid, the adrenal weight-increasing activity tends to fall rather than rise (Table 2). In these tests the rats were hypophysectomized two weeks previously and were given three intraperitoneal injections of pituitary extract (or 0·9 per cent sodium chloride in control animals) for three days, the animals being killed on the fourth day.

These results have led us to ascertain whether our postulated precorticotropin is present in the supernatant fluid of a homogenate of ox anterior pituitary tissue prepared without adjustment of *p*H. The results in Table 3 were obtained with homogenates prepared in 0·9 per cent sodium chloride of such volume that 1 ml. of homogenate was equivalent to 20 mgm. of tissue. The homogenate was spun in the high-speed centrifuge (approximately 18,000*g*) and the supernatant fluid diluted 20–50-fold with 0·9 per cent sodium chloride for biological testing.

The supernatant fluid prepared from the homogenate exhibits no activity in the Sayers test until the *p*H is adjusted to *p*H 3, when a significant appearance of such activity takes place (Table 3). The addition of urea to make a 6 *M* solution has a similar activating effect.

A whole homogenate of ox anterior pituitary tissue prepared by us does possess Sayers test activity, as also does the residue spun out in the preparation of the homogenate supernatant. It appears, therefore, that in the ox pituitary glands as we collect them only a portion of the total potential Sayers-active material is present as precorticotropin.

We have found, in agreement with others, that a dilute solution of corticotropin is very unstable in slightly alkaline medium. Thus, of a solution initially containing 40 μgm./ml., all may be lost in 2 hr. at

Table 3. ACTIVITY OF THE SUPERNATANT FLUID FROM AN OX ANTERIOR PITUITARY TISSUE HOMOGENATE IN THE SAYERS TEST

Change in adrenal ascorbic acid (μgm./100 mgm. adrenal weight)		
Supernatant diluted	Supernatant adjusted to *p*H 3·0 before dilution	Supernatant with 6 *M* urea before dilution
+ 11·5 ± 8 (17)	– 84 ± 8 (19)	– 61 ± 15 (4)

1 ml. of homogenate equivalent to 10 mgm. tissue; supernatant diluted 20–50 fold for biological test. The number of animals used in each test is given in parentheses

*p*H 7·4 at room temperature under the conditions of our experiments. It is very probable that any Sayers-active corticotropin initially present in our sterile crude alkaline pituitary extract will rapidly disappear. Nevertheless, since that extract may retain indefinitely its ability to acquire Sayers-test activity by suitable treatment, our precorticotropin appears to be stable in alkaline medium (*p*H 7–9).

Hall[15], Meites and Turner[16], and Carlisle[17] have all found little or no lactogenic activity, tested in rabbits, in crude anterior pituitary extracts, but have obtained from these crude extracts preparations of prolactin (luteotropin) which are highly lactogenic in their test animals. Carlisle[17] discusses the "artifactual nature of luteotropin" and writes: "it seems certain that luteotropin, as we know it in the extracted form, is an artifact which our methods of extraction have prepared from the inactive material of the primary extract. It is likely to be a different configuration of the same molecule, or of a fragment or multiple of it, for the only processes to which we have submitted it are unlikely to alter a protein to a greater extent than this". It should be noted that the galactopoietic activity of a crude ox pituitary extract (*FGS*) is very much greater than that of the prolactin which can be prepared from it[18], but growth hormone is largely responsible for this effect on milk secretion[19]. Dr. D. B. Carlisle has obtained results with corticotropin comparable with those he has seen with prolactin.

Since our precorticotropin is rendered active in the Sayers test by such mild treatments as adjustment of the *p*H of the solution to 3, or addition of urea (which might be expected to break hydrogen bonds) the change is unlikely to involve the fission of a covalent bond; that is, it is more likely to be a physical or a physico-chemical change than a chemical one. The nature of the change and its possible catalysis under biologically significant conditions, such as under the influence of enzymes, is under investigation. The question of the possible effect of our precorticotropin on the secretion of adrenal steroids also merits attention.

In the fresh homogenate of anterior pituitary tissue prepared by us, only a portion of the total corticotropin content is present as precorticotropin and is ineffective in the Sayers test. It is possible that the conditions of killing the animals from which the pituitary glands are obtained, or the time which elapses between the death of the animal and the preparation of the homogenate, may affect the proportion of the total corticotropin which may be obtained, in a form active in the Sayers test, in an alkaline extract. This is a subject for further investigation. What is clear at present is that the sterile crude alkaline extract of ox anterior pituitary tissue (*FGS*) which we have prepared and used in previous investigations[1–4] can possess no activity in the Sayers test but, nevertheless, can acquire such activity after mild treatment. That precorticotropin is itself responsible in part for the adrenal weight-increasing activity of crude anterior pituitary extracts is probable but not certain. It is, nevertheless, very likely that the presence of such precorticotropin in a crude alkaline extract of ox pituitary tissue accounts for the striking discrepancies between the results of tests for Sayers activity and for adrenal weight-increasing activity of such extracts, previously observed in this laboratory[1–4,6]. Moruzzi *et al.*[20] have described the presence in blood of two forms of corticotropin. One called 'active' corticotropin is a labile and ultrafilterable fraction found in the blood of normal subjects. The other, named 'activable' corticotropin, is detectable (by a Sayers type of test) only after treatment with oxycellulose. This form of corticotropin, according to Moruzzi *et al.*[20], occurs in the blood of human subjects with Addison's disease and other conditions in which adrenal function is deficient. More recently, Jailer *et al.*[21] have found activity in the adrenal weight test with plasma from patients with Cushing's syndrome due to bilateral adrenal hyperplasia and from pregnant women. No Sayers-test activity was found with plasma from the two patients with Cushing's syndrome whose plasma was tested in this respect. A relationship of these factors to our precorticotropin and also to that described by Golla and Reiss[22] in the serum of pregnant mares is possible but by no means certain.

One of us (P. R. D.) held a Colombo Plan Scholarship from the Government of India during the period that this work was carried out. The expenses of this investigation were partly defrayed from an expense grant from the Medical Research Council to one of us (F. G. Y.).

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A Crustacean Chromactivator

IT is an old observation that colour change of Crustacea is brought about by the action of certain chromactivating substances, the best known of which are released into the blood by the sinus gland of the eye-stalk. In 1955, Knowles, Carlisle and Dupont-Raabe[1], working on *Leander serratus*, showed that the material stored in the sinus gland, substance *A*, was the precursor of three or more blood-borne substances, the α-substances, which themselves acted upon the chromatophores, while substance *A* was never apparently released from the gland. The evidence suggested that the conversion of the large molecule of substance *A* into the smaller dialysable molecules of the α-substances was enzymatic. The sum of the activities of the α-substances was about equal to the activity of the parent substance *A*.

It has repeatedly been observed that the total chromactivity of an eye-stalk extract is increased twofold or more by boiling. But in this laboratory we have found that boiling an extract of a sinus gland does not affect the total activity (it does, however, prevent the conversion of the native substance *A* into the α-substances). A fresh extract of the remainder of the eye-stalk, after removal of the sinus gland, contains little or no chromactivity; but if such an extract is boiled, it gains an activity about equal to that of the sinus gland extract.

It is generally accepted that the greater part of the hormonal material found in the sinus gland is not actually produced there, but is first formed in the neurosecretory cells of the medulla terminalis ganglionic *X*-organ and of other ganglionic *X*-organs within the eyestalk. In fact, when boiled extracts are prepared from various fractions of the eyestalk, almost the total chromactivity is found in the sinus gland and the medulla terminalis ganglion *X*-organ. Unboiled extracts of the latter organ show no chromactivity. Electrophoretic examination of the boiled extracts of the organ reveal that they contain substance *A*, with no trace of the α-substances. When I dissected out the nerve connecting the organ with the sinus gland, I found that the proximal part, near the organ, yielded extracts which were inactive until boiled, while the distal part yielded extracts which were active when fresh. It is noteworthy that the staining reactions of the *X*-organ and sinus gland differ from one another, and that the proximal part of the connecting nerve tract stains like the *X*-organ while the distal part stains like the sinus gland. The substance present in the *X*-organ is apparently the precursor of substance *A*, and becomes converted into substance *A* during its passage along the nerve tract.

It is of interest to examine the range of treatments which will activate the inactive chromactivator of the *X*-organs. Besides boiling, this can be brought about by the action of acetone (especially if this is slightly acidified), alcohol, trichloracetic acid, formalin and urea. From this it would appear that it is sufficient to break hydrogen bonds to activate the material; the change involved is rather physicochemical than chemical.

The effect of mild treatment in activating a previously inactive storage substance is comparable to the observations I have previously made[2] upon the effect of similar agents in producing a prolactational or a corticotropic activity from inactive crude pituitary extracts. It may also be compared with the observations presented by Dasgupta and Young (preceding communication).

The earliest of the series of experiments on which this communication is based were noticed briefly by Knowles[3], who also reproduces a colour photograph taken in this Laboratory of the colour changes involved.

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RESPONSES OF THE ANTERIOR RETRACTOR MUSCLE OF THE BYSSUS OF *MYTILUS EDULIS*

In a recent study of muscle from *Mytilus edulis*, Hoyle and Lowy[1] have discussed the action of 5-hydroxytryptamine in producing relaxation of the tonically contracted anterior retractor muscle of the byssus. They comment on the fact that the muscle may fail to recover its ability to respond to d.c. stimulation by tonic contraction for several hours after exposure to 5-hydroxytryptamine; in some examples up to 40 hr. were required for recovery. They infer from this that 5-hydroxytryptamine is unlikely to be the substance normally responsible for relaxation in the intact animal (cf. Twarog[2]). The concentrations of 5-hydroxytryptamine used by Hoyle and Lowy were, however, of the order 1–10 μgm./ml. and it is of interest that relaxation can be obtained using concentrations as low as 10–0·5 mμgm./ml. This action is best shown when a tonic contraction has been induced by acetylcholine 1 μgm./ml. The effect of 5-hydroxytryptamine applied at the peak of contraction is to increase the initial rate of relaxation. Using concentrations as stated, repeatedly reproducible responses can be shown (Fig. 1).

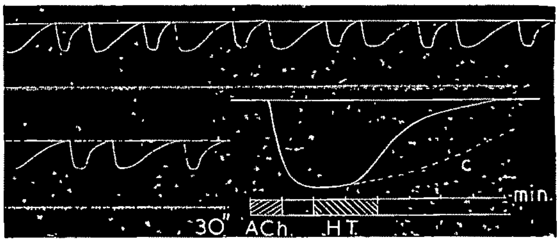

Fig. 1. Record of the isometric responses of the anterior retractor muscle of the byssus (contraction downwards). Contraction induced by acetylcholine (1 μgm./ml.) and alternate records show the relaxation under sea water control and following 5-hydroxytryptamine (10 mμgm./ml.). Inset, diagram showing the time of application of the drugs. Dotted line (*c*) indicates the course of control relaxation

As reported previously[3], this relaxing effect of 5-hydroxytryptamine can be demonstrated on a muscle in a state of tonic contraction induced by electrical stimulation alone, or by the combined effects of electrical stimulation and noradrenaline, or by the application of acetylcholine, the latter giving the most consistent results.

Hoyle and Lowy state further that since the anterior retractor muscle of the byssus is unable to destroy 5-hydroxytryptamine the effects produced by the drug are of pharmacological interest only. Blaschko[4] has reported the presence of amine oxidase in the muscle. That amine oxidase is an enzyme capable of destroying 5-hydroxytryptamine is now well known.

Although the findings reported above do not serve to prove that 5-hydroxytryptamine is the naturally

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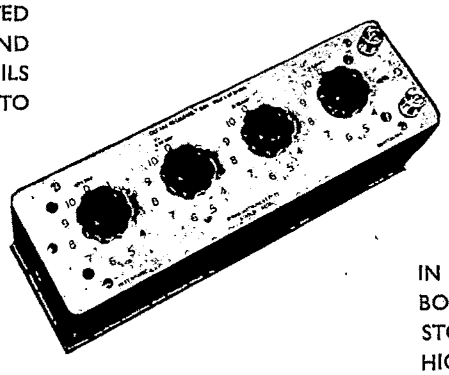

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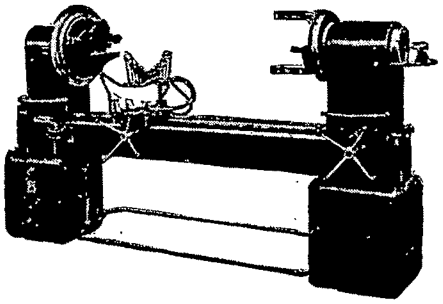

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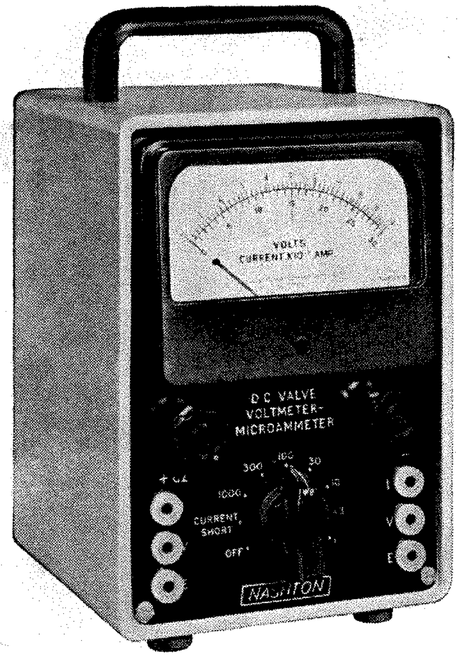

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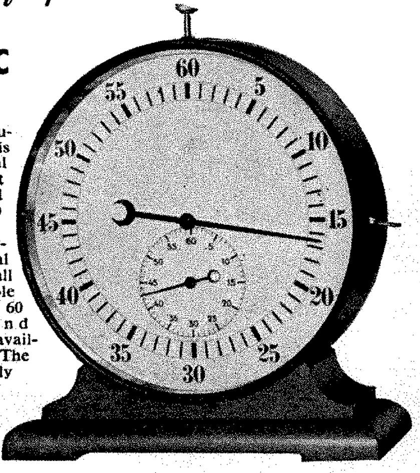

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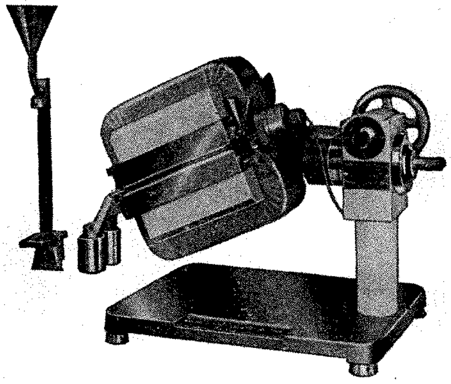

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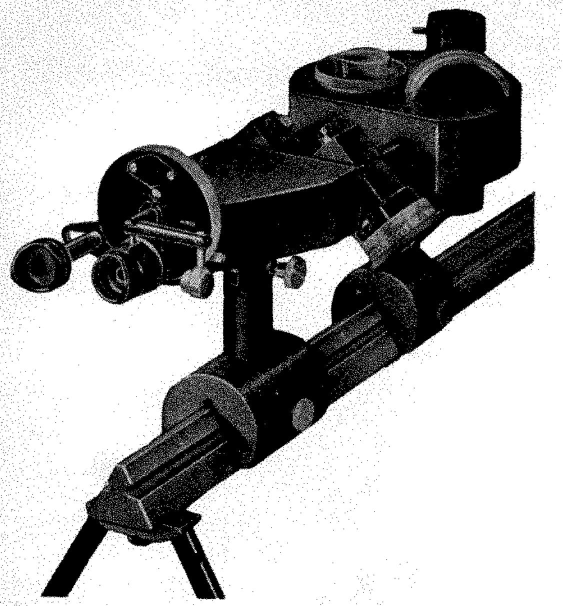

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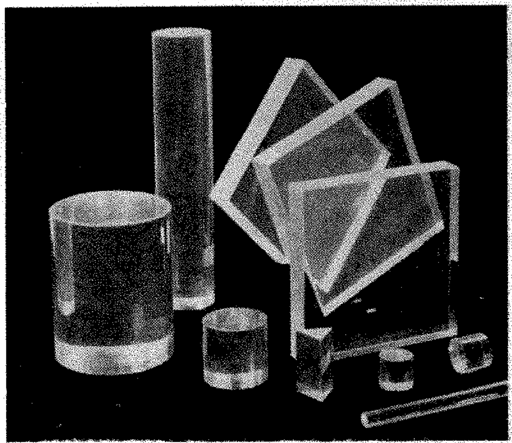

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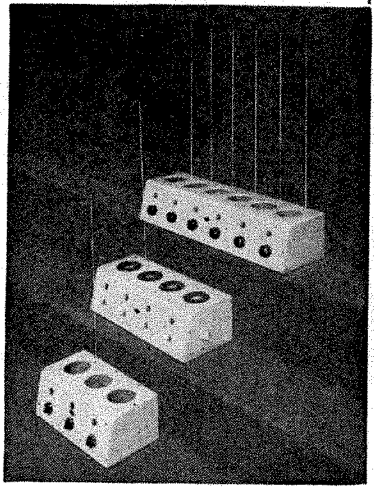

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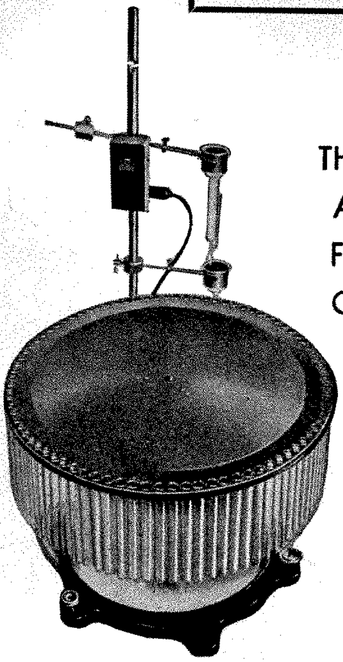

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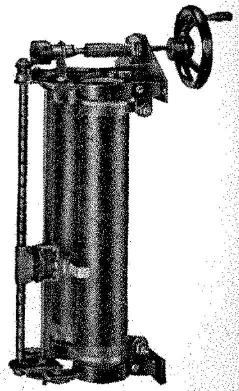

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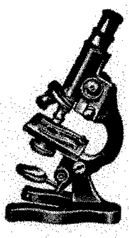

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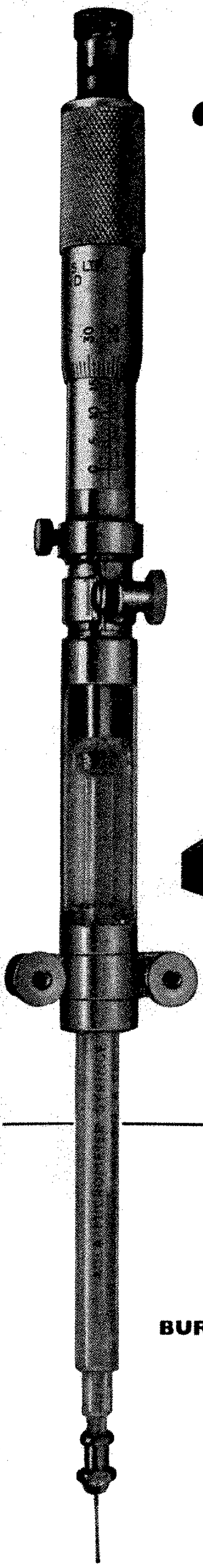

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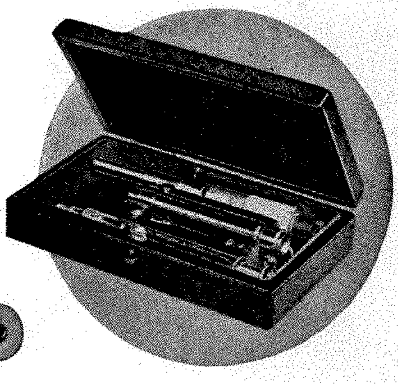

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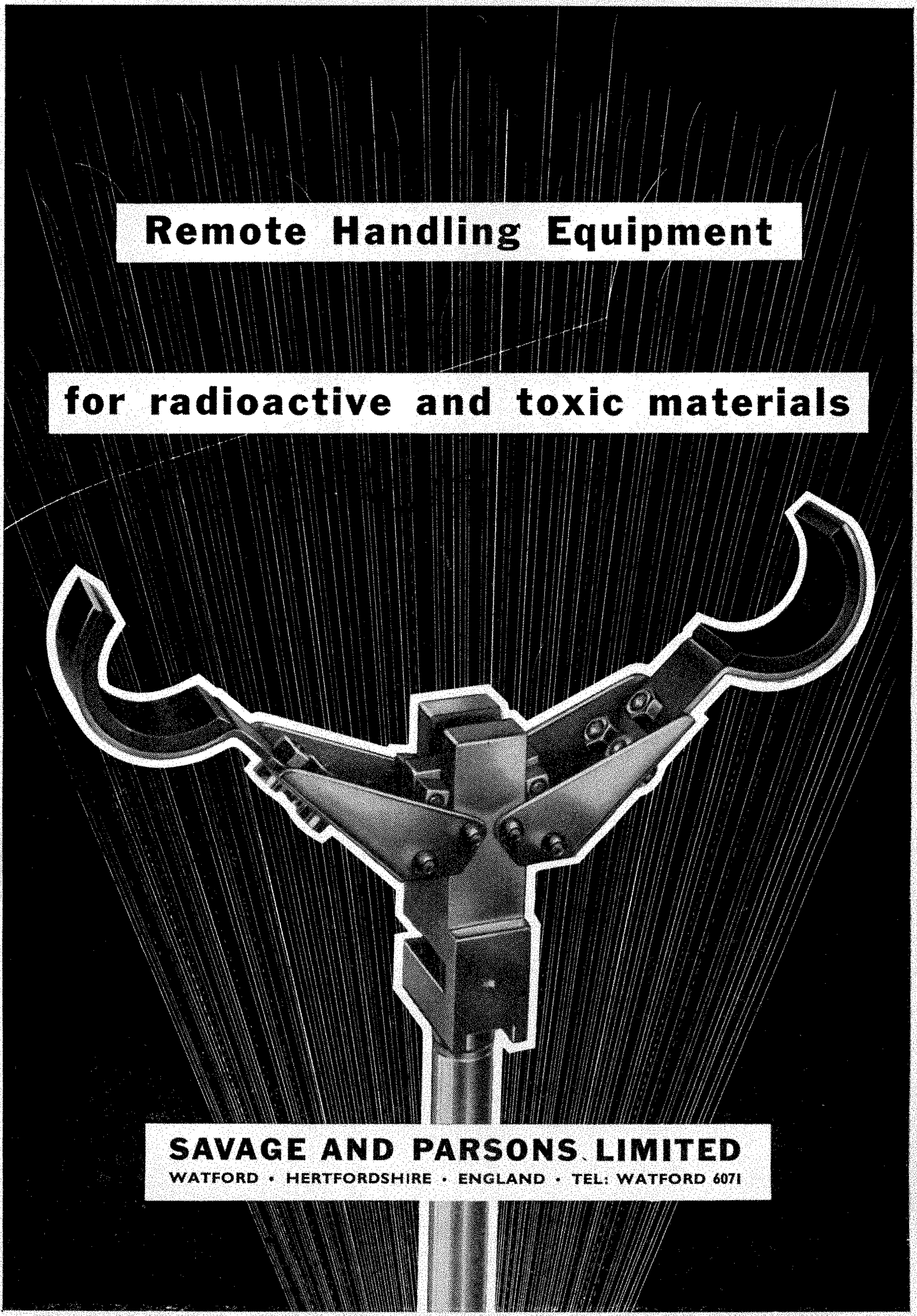

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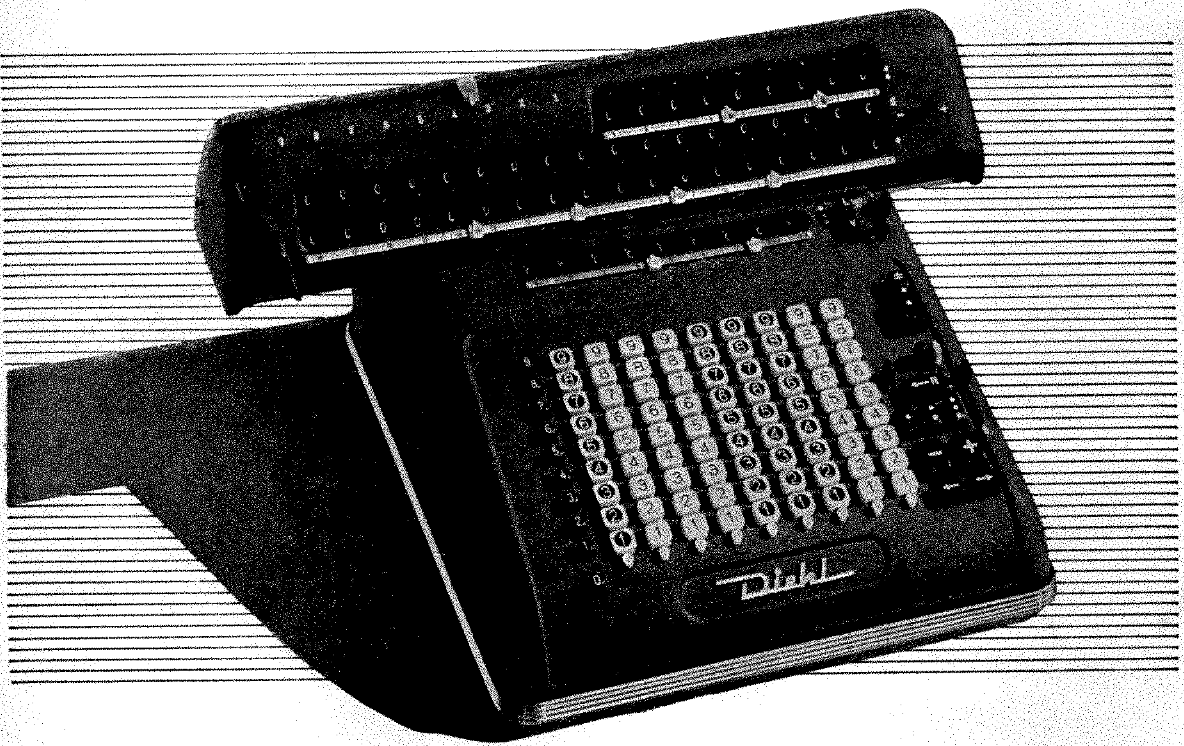

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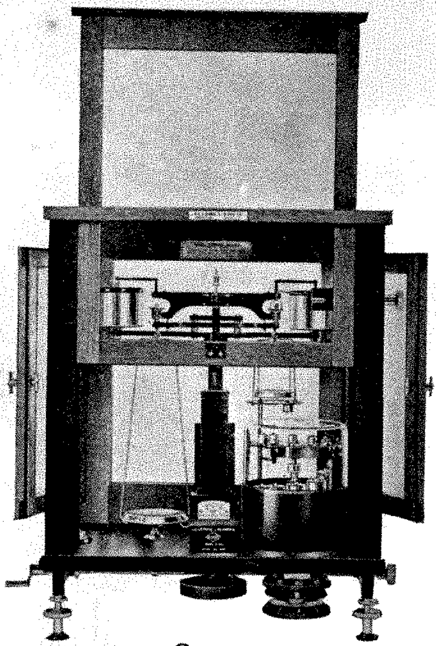

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[1] Hoyle, G., and Lowy, J., *J. Exp. Biol.*, **33**, 295 (1956).

[2] Twarog, B. M., *J. Cell. Comp. Physiol.*, **44**, 141 (1954).

[3] Cambridge, G. W., and Holgate, J. A., *J. Physiol.*, **130**, 22*P* (1955).

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Recently, Evans and Schild[1] have examined the effects of electrical stimulation and drugs on vertebrate smooth muscle which had been depolarized by the external application of potassium ions. The conducted response to electrical stimulation was abolished under these conditions but the contraction in response to drugs, presumed to be due to local excitation of smooth muscle cells, was maintained. Experiments on invertebrate smooth muscle, the anterior retractor muscle of the byssus of *Mytilus edulis*, have given results which differ from these. This muscle can be depolarized by exposure to 0·56 *M* potassium chloride and this produces, under isometric conditions, a prompt development of tension which is maximal in about 10 sec., and relaxation occurs over a period of 30–40 sec. The muscle is then inexcitable by electrical stimulation (either d.c. which normally produces a tonic contraction or 2-m.sec. pulses 4/sec. which normally produce a phasic contraction), and it also fails to respond to acetylcholine in concentrations up to 2 μgm./ml. The course of depolarization of the muscle by potassium chloride was determined by Twarog[2], who found the maximum potential on depolarization was obtained 20–25 min. after the potassium chloride contraction, and in the experiments reported above the responses to electrical stimulation and drugs were examined within this period. Soaking in sea water restored the excitability to electrical stimulation and to drugs.

Owen[3] reported that lamellibranchs could be narcotized and caused to relax by exposure to propylene glycol monophenyl ether ('Propylene phenoxetol'), and preliminary experiments indicate that the anterior retractor muscle of the byssus may be rendered insensitive to electrical stimulation and to acetylcholine by soaking in a 0·25 per cent solution of this compound in sea water. Furthermore the contraction produced by 0·56 *M* potassium chloride is abolished under these conditions ; the effect of phenoxetol is reversible on soaking the muscle in sea water.

A further agent which may be of value in differentiating the mode of action of drugs and electrical stimulation on the membrane is the toxin from *Gymnodinium veneficum*[4] which is presumed to render nerve and muscle, including the anterior retractor muscle of the byssus, inexcitable by increasing the permeability of the membrane to sodium ions. So far, experiments I have made with the impure toxin have not yielded clear-cut results, a marked change in threshold occurring rather than an absolute failure of response to stimulation.

Details of this investigation, including the effects of other ions on the response of the muscle to drugs, will be reported elsewhere.

I wish to thank the Director of the Marine Biological Association Laboratory for the facilities placed at my disposal at Plymouth, and to acknowledge a personal grant from the Browne Research Fund of the Royal Society which enabled me to undertake this work.

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ACTION OF HYDROCORTISONE ON RESPIRATION OF HUMAN CANCER CELLS IN TISSUE CULTURE

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A PRIMARY human epidermoid cancer of the larynx, *H.Ep.*2(Toolan), was transplanted into X-irradiated and cortisone-treated rats[1], and, after two generations in rats, has been grown in tissue culture since September 1952 [2]. The tissue culture cells when re-implanted into an irradiated, cortisone-treated rat form a typical epidermoid cancer. In tissue culture these cells, growing on the glass surface of T-60 flasks[3], form dense epithelial sheets very much like the original epidermoid cancer. Their rate of growth is relatively high, and their number doubles in about three days[2]. In the following experiments the culture medium consisted of 10 per cent of half-diluted embryo extract, 40 per cent horse serum, and 50 per cent Earle's balanced salt solution containing 0·22 per cent sodium bicarbonate and phenol red as *p*H indicator. Cultures of several flasks were thoroughly scraped from the glass surface, the cell suspensions pooled, and 5 ml. were put in each of four T-60 flasks. 0·5 ml. of the pooled cell suspension was used for enumeration of cell nuclei in the hæmocytometer[5], after trypsinization. Except for enumeration of cell nuclei, no trypsinization was used. Approximately equal distribution of cells in the four T-60 flasks was achieved by continuous mixing of the stock suspension with a pipette. 5 ml. of fresh medium were then added to each of the four flasks, and to two of them hydrocortisone in a final concentration of 0·62–1·25 γ per ml. Since the hydrocortisone stock solution contained 50 per cent ethanol, ethanol in the same dilution was added to the control flasks. Hydrocortisone was added to the cultures 3–4 times at intervals of about three days, and also to the Warburg vessels before they were attached to the manometers.

The medium of the four T-60 flasks was completely removed with a Pasteur pipette, and to each flask 3 ml. of fresh medium were added. The cells of the

Table 1. Human Cancer growing in Cortisone-treated Rats and in Tissue Culture

Exp.	Q_{O_2} (10^{-5} µl. O_2/hr./cell) Control	Q_{O_2} (10^{-5} µl. O_2/hr./cell) Hydrocortisone	$Q^{O_2}_{CO_2}$ (10^{-5} µl. CO_2/hr./cell) Control	$Q^{O_2}_{CO_2}$ (10^{-5} µl. CO_2/hr./cell) Hydrocortisone
		Strain *H.Ep.* 2		
1	– 0·23	– 0·33	0·85	1·0
2	– 0·35	– 0·55	0·85	1·25
3	– 0·30	– 0·50	0·40	0·70
4	– 0·43	– 0·85	0·95	1·10
Average	– 0·33	– 0·56	0·76	1·0
		Strain *L*		
1	– 0·66	– 1·0	0·50	0·80
2	– 0·80	– 1·40	0·60	0·90
3	– 0·50	– 0·80	0·30	0·60
4	– 0·87	– 1·46	0·44	1·46
Average	– 0·71	– 1·14	0·46	0·94

two hydrocortisone-treated *T*-60 flasks were thoroughly scraped from the glass surface and the 6 ml. of cell suspension pooled in a large tube. The cultures of the two control flasks were treated in a similar manner. 3 ml. of the hydrocortisone pre-treated cell suspension were put in a Warburg vessel, the centre well of which contained 0·2 ml. of 15 per cent potassium hydroxide, for measurement of oxygen uptake, and the remaining 3 ml. of the cell suspension were put in a Warburg vessel with 0·2 ml. saline in the centre well for measurement of carbon dioxide evolved. The pooled 6 ml. of cell suspension from the control *T*-60 flasks was equally divided and put in two Warburg vessels, one for the measurement of oxygen consumption and one for measurement of carbon dioxide production. 0·5 ml. of Earle's saline containing hydrocortisone was added to each of the two Warburg vessels containing the cell suspensions pretreated with hydrocortisone, and 0·5 ml. of Earle's saline without hydrocortisone was added to each of the control vessels.

Measurements of respiration and aerobic glycolysis of strain *L* cells derived from a fibroblast of normal subcutaneous tissue of the mouse were carried out in the same way, and the results compared with those obtained from human cancer cells of the larynx. Strain *L* was producing tumours in 1942 in 68 per cent, but in 1946 the incidence of sarcomas produced by strain *L* dropped to 1 per cent. Strain *L* has been carried in this laboratory since 1954. Growth-rate of both strain *H.Ep.*2 and strain *L* was estimated by nuclear counts. Inocula of about equal size were put into six flasks and on three consecutive days nuclear counts of two flasks were carried out.

In Table 1 the rates of respiration and of carbon dioxide production are compared with those of strain *L*. The Q_{O_2} and $Q^{O_2}_{CO_2}$ represent average values obtained over a period of 3 hr. With the strain *L* line, respiration is 100 per cent higher than with cancer cells. This applies to cells treated with hydrocortisone as well as to the control cultures. In control cultures, aerobic glycolysis is 67 per cent higher in cancer cells than in the strain *L* fibroblasts. In hydrocortisone-treated cultures, aerobic glycolysis is only 6 per cent higher in cancer cells than in strain *L* fibroblasts.

It is noteworthy that the ratio of aerobic glycolysis to respiration in strain *L* fibroblasts is 0·64 (46 : 71), while in human cancer cells the ratio is 2·3 (76 : 33).

With regard to the effects of hydrocortisone, aerobic glycolysis was more than doubled with strain *L* cells and increased only by 33 per cent with the human cancer cells. Hydrocortisone increased respiration in the two cell strains by 66 and 57 per cent respectively.

The ratio of aerobic glycolysis to respiration was increased by hydrocortisone from 0·64 to 0·81 with strain *L* cells and was decreased from 2·3 to 1·8 with the human cancer cells (Table 1).

Figs. 1 and 2 depict the respiration and carbon dioxide production of the human cancer and strain *L* cells, with and without hydrocortisone over a period of 4 hr. It is evident that the effects of hydrocortisone are consistent throughout the period of observation.

Fig. 3 shows the comparative rates of growth of the two cell types in tissue culture.

Respiration and glycolysis of fibroblasts in tissue culture have been studied by a number of investigators[6–19]. Most authors have found high anaerobic as well as aerobic glycolysis and a rather low ratio of aerobic glycolysis to respiration. Some, however, have reported that the ratio of aerobic glycolysis to respiration is as high in normal tissue cultures as in

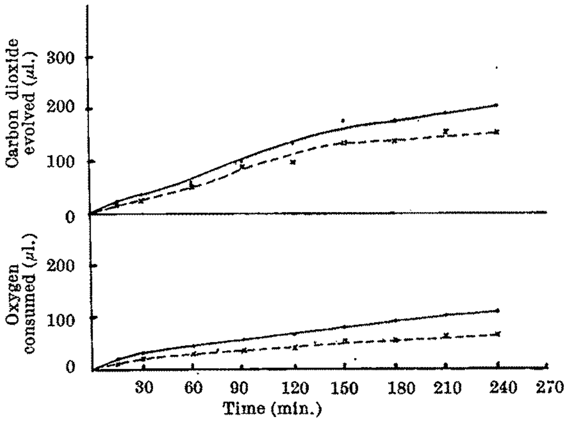

Fig. 1. Respiration and glycolysis of human cancer cells. Average of four experiments. ——, with hydrocortisone ; – – –, control

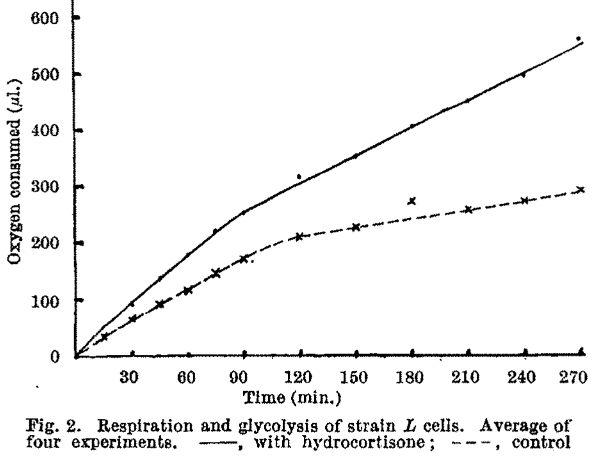

Fig. 2. Respiration and glycolysis of strain *L* cells. Average of four experiments. ——, with hydrocortisone ; – – –, control

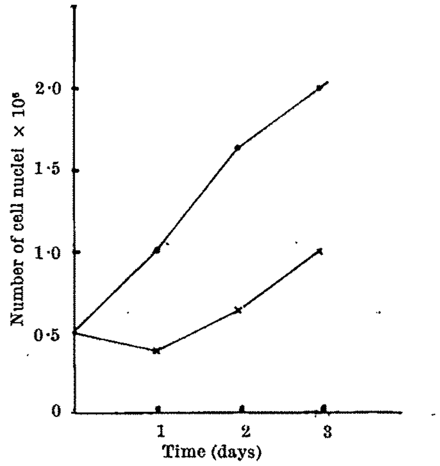

Fig. 3. Comparative rates of growth of two cell types in tissue culture. Top, strain *L*; bottom, *H.Ep.*2

malignant tumours[15]. The present results show a fairly high aerobic glycolysis of strain *L*, but a low ratio of aerobic glycolysis to respiration.

Early investigators postulated a fundamental relationship between glycolysis and growth, and even a dependence of growth on glycolysis. (The decline of growth with the age of the embryo was at one time related to the decline of the intensity of glycolysis.) In later work any fundamental relationship between growth and glycolysis has been denied[16,17]. The present results likewise demonstrate that high glycolysis in tissue culture is not related to rapid growth. The high aerobic glycolysis of cancer cells in tissue culture is not associated with a higher rate of growth, for the cancer cells in the present study actually grow at a rate considerably less than that of the strain *L* (Fig. 3). The high aerobic glycolysis of *H.Ep.*2 cells appears thus to be due to a specific feature of malignancy, but may be here in part secondary in nature, resulting from a depression of respiration.

It has been reported[18] that 2,4-dinitrophenol stimulates the respiration of both malignant and non-malignant cells, and that under the influence of dinitrophenol the respiration of the malignant cells approaches that of normal cells. This was considered as inconsistent with the theory of irreversibility of the respiratory defect of cancer cells.

In the present studies hydrocortisone increased the respiration of human cancer cells and of strain *L* cells to a similar degree. Thus even the improved respiration of human cancer cells remains well below that of strain *L*.

I wish to thank Drs. John V. Taggard and LaRoy S. Dietrich for helpful discussions. This work was aided in part by U.S. Public Health Service Grant *A*-21.

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THE IMPACT TESTING OF EXPLOSIVES

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FOR many years the sensitivity of explosives has been measured by one form or another of impact test. This test is usually arranged so that a weight is dropped, from a series of heights, on many individual samples of the explosive under study, to determine whether or not each sample explodes. The range of height is chosen, by trial and error, so that the lowest height rarely, and the greatest height almost always, initiates an explosion. In this way one obtains a curve showing percentage initiation (fractional fires) as a function of drop-height. Powdered explosive is almost always used. The sample struck by the falling weight may be heaped in a conical pile upon a flat surface, or confined to varying degrees in a metal or plastic container. When the sample is completely contained, the impact of the falling weight is transmitted through the container wall either by compression or shearing through it. In some tests the falling weight strikes the exposed or confined explosive directly, and in this case the weight is usually a metal sphere. Often the energy of the weight is transmitted to the powder or its container by striking a flat, rounded or pointed pin. Here we employ data obtained with the Picatinny Arsenal impact machine, which is a typical version of these devices. In this machine the powder is contained in a shallow dish-like indentation cut in one end of a flat steel cylinder. A controlled amount of sample, filling the hollow, is confined by a thin brass cap which is pressed over the indentation. A flat steel disk with a slot cut along one diameter is placed, slot side down, directly in the centre of the brass cap over the powder. The falling weight then strikes this cylindrical pin, which transmits the energy of impact to the container and its powder.

When one attempts to use a curve of percentage fires against drop-height, obtained with any of these machines, to derive information about the explosive properties of the samples being tested, one is faced by what appear to be very complex analyses. Two examples of the kind of information one would like to obtain from these analyses are: How is the impact energy divided between sample and container, and what is the maximum instantaneous temperature reached by any part of the explosive ? Even with

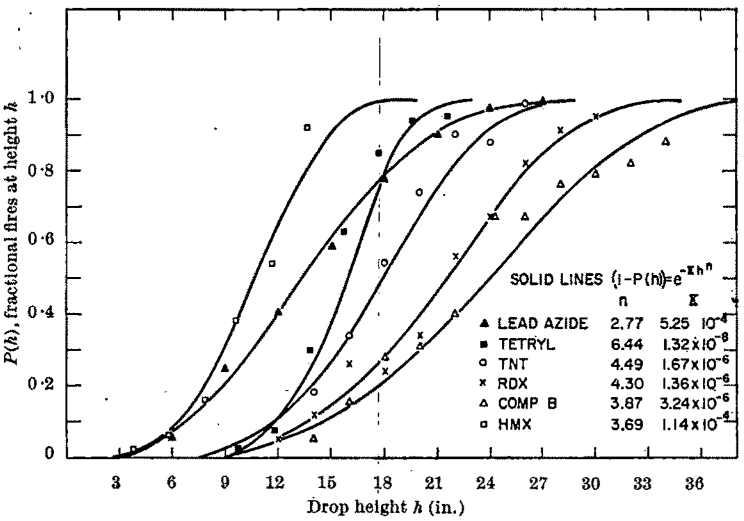

Fig. 1. Fractional fires versus drop-height for various explosives obtained with a Picatinny Arsenal-type machine. The equation $\{1 - P(h)\} = \exp(-Kh^n)$ has been fitted to the data using the constants tabulated

the simplest impact machines, in which the powder is compressed between flat plates, calculation of any mechanical property of the explosive under impact is practically impossible. However, an equation may be derived from which one may obtain information about some of the properties of the explosive under study, and in addition, information on the mechanical properties of the impact machine. This equation will be derived for an explicit set of assumptions, but it must be emphasized that the same result may be obtained with similar but different assumptions.

First, consider that in an impact machine the energy imparted to the explosive is a function of drop-height. Also, assume that the explosion will be initiated if energy in excess of a fixed critical amount is imparted to a region of the powder, or a region of a crystal in the powder, that contains at least one 'site' possessing the requisite properties for initiating the detonation. These sites may be, for example, hot spots[1], bubbles, crystals in the correct juxtaposition to detonate when pushed together, or some crystalline or molecular arrangement the relation of which to detonation is not yet understood. Let the volume of explosive energized in excess of the critical energy necessary to activate a site, by a weight falling from height h, be $V(h)$, where h is in inches. Assume that the density of sites, C per unit volume, is small and that they occur at random so that they are distributed according to Poisson statistics among the numerous crystallites. A detonation will occur if the volume $V(h)$ contains at least one site; likewise, a detonation will not occur if $V(h)$ is devoid of sites. From Poisson statistics the probability that the volume $V(h)$ contains *no* sites is $\exp\{-CV(h)\}$. Let the probability that a drop from height h produces a fire be $P(h)$. (Actually $P(h)$ will be the fraction of fires occurring for height h.) Then:

$$\begin{aligned} P(h) &= 1 - \text{probability of no fires} \quad (1)\\ &= 1 - \exp\{-CV(h)\} \end{aligned}$$

Given data showing $P(h)$ versus h, such as those used to construct Fig. 1, we see that by writing (1) as

$$CV(h) = -\ln\{1 - P(h)\} \qquad (2)$$

a plot of $-\ln\{1 - P(h)\}$ versus h will give a curve proportional to $V(h)$. Incidentally, if we had an independent way of determining $V(h)$ we could determine the concentration of sites, C, from this equation. A plot of this type, Fig. 2, was constructed from all the data shown in Fig. 1, which were obtained with impact machines of the Picatinny Arsenal type, and from one additional set of data, the points shown for copper chlorotetrazole. These additional points, obtained with a machine in which the explosive is pressed into an open cylinder and the impact of the falling ball is transmitted to the explosive with a pointed pin that is in contact with it, are included to indicate that the $V(h)$ functions for the two machines are somewhat different. The lead azide data are from unpublished work by J. E. Abel, R. W. Dreyfus, J. V. R. Kaufman and P. W. Levy. The results for copper chlorotetrazole were obtained especially for this article by A. Forsyth. All other data are from A. Bullfinch, Picatinny Arsenal Technical Report 2282 (unpublished).

The points obtained with the Picatinny Arsenal machine suggest that the function $V(h)$ is the same for all the materials listed and has the form kh^n. Considering the complex nature of the explosive container, this is a reasonable expression. Putting $V(h) = kh^n$ into (1) we obtain:

$$P(h) = 1 - \exp(-Ckh^n) = 1 - \exp(-Kh^n) \qquad (3)$$

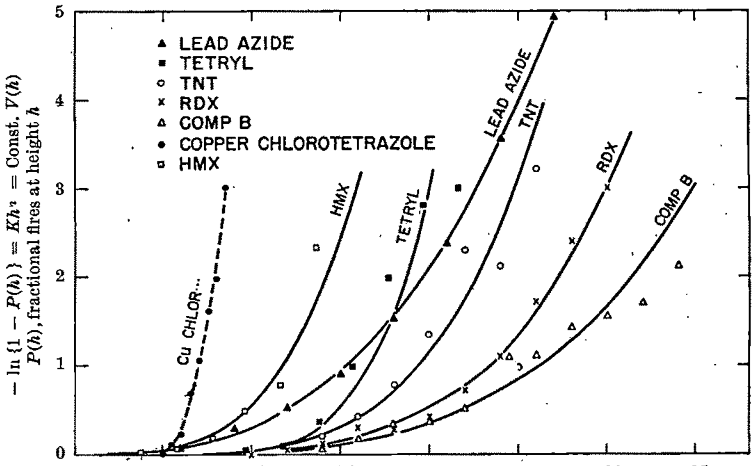

Fig. 2. The $V(h)$ function, which can be determined to within a scale factor from impact data, for results obtained with the Picatinny Arsenal-type impact machine, with one curve (copper chlorotetrazole) for a different type of impact machine; the $V(h)$ functions for the two machines are somewhat different. For the Picatinny Arsenal-type machine $CV(h)$ is of the form : const. × $kh^n = Kh^n$. The solid lines represent this expression computed with the constants shown on Fig. 1

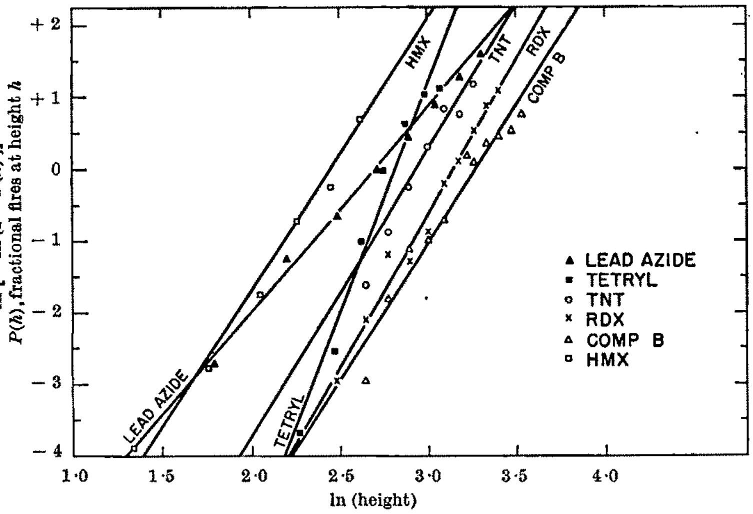

Fig. 3. ln [− ln {1 − $P(h)$}] versus ln h should be a straight line if equation (3) applies to the data. Because of the well-known inadequacies of log–log plots this cannot be considered a good test. However, these plots are a convenient device for determining n and K and the parameters tabulated in Fig. 1 were obtained from them

which emphasizes that K is the product of two constants. By writing this as:

$$\ln K + n \ln h = \ln [- \ln \{1 - P(h)\}]$$

we can test, subject to the usual inadequacies of log–log plots, the applicability of (3), since a plot of ln [− ln {1 − $P(h)$ }] versus ln h should be a straight line of slope n. Fig. 3 is such a plot, for the data represented on Fig. 1, and it appears to be in reasonable agreement with these ideas. Furthermore, these plots are a convenient device for determining the parameters n and K. In order to determine n and K in a consistent manner, the lines shown in Fig. 3 were fitted by the method of least squares even though the data do not warrant this. The values of n and K so obtained are shown in Fig. 1 and the solid lines in Figs. 1 and 2 were computed from them. The dashed curve in Fig. 2 is drawn through the copper chlorotetrazole data to indicate the difference between it and the other curves. Note that n depends only on the mechanical properties of the explosive and its container, whereas K depends on both the mechanical properties and on the concentration of initiation sites. Thus, if one changes the number of sites in an explosive while leaving the mechanical properties unchanged, this would be reflected by a change in K, but n would remain unchanged.

Once the validity of equation 1 in the form that applies to a given impact machine and explosive has been established, it is no longer necessary to determine the entire fractional fire versus drop-height curve to characterize a sample. It is necessary to measure only enough points on this curve to determine the parameters in the equation; for example, only two points are necessary to determine equation (3) for the Picatinny Arsenal machine. Even though this treatment may give some insight into the results obtained with impact machines, a great deal of additional work must be done before these machines will be really useful tools for investigating the initiation process. For example, one possibility is a detailed study of impact machines by static and dynamic photoelastic analogues.

I wish to acknowledge the encouragement of Dr. J. V. R. Kaufman, of Picatinny Arsenal, and I am also indebted to two other members of the Picatinny staff, Mr. J. E. Abel for preparing the figures and for computations, and Mr. A. Forsyth for the results obtained with copper chlorotetrazole. This work was supported jointly by the U.S. Atomic Energy Commission and Picatinny Arsenal.

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CONTINUOUS TIME TREATMENT OF A STORAGE PROBLEM

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IN the storage problem considered initially by Moran[1] for discrete time, the content $Z_t(0 \leqslant Z_t \leqslant K - M)$ of a finite dam of capacity K is specified at the discrete times t ($t = 1,2, \ldots$) by the equation

$$Z_t = \mathrm{Min}\,(Z_{t-1} + X_{t-1}, K) - \mathrm{Min}(Z_{t-1} + X_{t-1}, M) \qquad (M < K)$$

where, during $(t - 1, t)$, (1) independently distributed inputs X_{t-1}, each with probability distribution function $dG(x)$, $(0 \leqslant x < \infty)$, flow into the dam; (2) $\mathrm{Min}(Z_{t-1} + X_{t-1}, K)$ indicates that any excess of $Z_{t-1} + X_{t-1}$ over K overflows; and lastly (3) a release $\mathrm{Min}(Z_{t-1} + X_{t-1}, M)$ is made just before the time t.

For Z_t, X_t, M, K discrete, $\{Z_t\}$ is known to be a Markov chain, and equations may be framed for its stationary probability distribution in terms of the discrete input distribution $dG(x)$. By using limiting methods on this model, Moran[2,3] and Gani[4] have obtained some stationary solutions of the storage problem in continuous time. In these cases the procedure has proved cumbersome and, at least in the process described below, has obscured the simplicity of the underlying model. For this Poisson-type process, it has been possible to obtain directly the forward Kolmogorov equation which can be solved by straightforward methods.

Consider the dam of finite capacity K, the content $Z(t)$ of which is defined in continuous time $t(0 \leqslant t < \infty)$ by the equation:

$$Z(t + \delta t) = \mathrm{Min}\,\{Z(t) + \delta X(t), K\} - \mathrm{Min}\,\{Z(t), \delta t\}$$

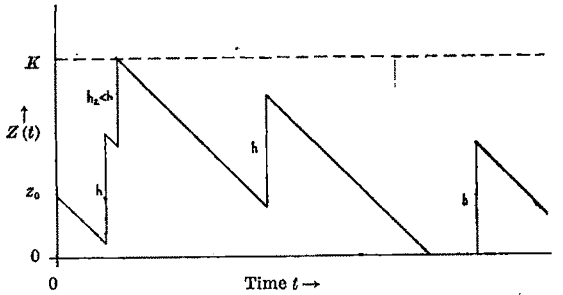

Fig. 1

$X(t)$ is a Poisson process with parameter λ such that in time δt, the input $\delta X(t)$ of either h or no units flows into the dam; the release is continuous, occurring at a constant rate when $Z(t) > 0$, and any excess of $Z(t)$ over K overflows. It is easily seen that $\{Z(t)\}$ is a time-homogeneous Markov process, of which Fig. 1 will illustrate a realization. In this particular case, the second input is effectively less than h owing to the overflow rule, and the dam remains empty for a while after the third input.

This is actually the basic model used by both Moran[2] and Gani[4]; in Moran's model, however, the content is equal to our $K - Z(t)$, the input to our steady release and the release to our input h. In the discrete form, owing to the different formulations of the problem, the identity of the model was not recognized, and slightly different expressions for the stationary distribution of the dam content were obtained, which are in effect identical.

Let us denote by $\mathrm{F}(z,t)$ the transition probability function $\mathrm{F}(z_0, \tau; z, \tau + t)$ of the process $\{Z(t)\}$; the forward Kolmogorov relation is the differential-difference equation:

$$\frac{\partial F}{\partial t} - \frac{\partial F}{\partial z} = -\lambda\{F(z,t) - F(z-h,t)\} \quad (0 \leqslant t < \infty) \qquad (1)$$

a special form of Takacs's[5] more general equation, which is valid in every part of the range $0 \leqslant z \leqslant K$, including its end points. In addition, $\mathrm{F}(z,t) = 0$ for $z < 0$, and $\mathrm{F}(K,t) = 1$, for all t. When $K \to \infty$, the equation continues to hold.

To find the stationary distribution $\Phi(z) = \lim_{t \to \infty} F(z,t)$, $\frac{\partial \mathrm{F}}{\partial t}$ is put equal to zero in (1) and $\Phi(z)$ then satisfies the equation:

$$\frac{\partial \Phi}{\partial z} = \lambda\{\Phi(z) - \Phi(z-h)\} \quad (0 \leqslant z \leqslant K) \qquad (2)$$

where $\Phi(z) = 0$ if $z < 0$, and $\Phi(K) = 1$; this leads to the results already obtained by the two different approaches mentioned. When K is infinite, a stationary solution exists if the condition $\lambda h < 1$ is satisfied, and it can now be seen that the solution here remains of a form identical with that of the known finite case. In effect, the solution for the finite dam is the truncated infinite solution with suitable scaling for $\Phi(K)$ to be equal to unity. It is now also possible from equation (2) to find the previously unknown Laplace–Stieltjes transform of the stationary distribution and to derive from it the various moments of $Z(t)$. These results, closely connected as they are with previous work, help to clarify the stationary distribution considerably.

Returning to equation (1), for the specific case where K is taken to be infinite, it is now seen that the time-dependent solution for the transition probability function $\mathrm{F}(z,t)$ can be found. In order to do this it is necessary to consider the probability $g(z_0,t)$ that, starting with a content z_0 at time τ, the dam becomes empty at time $\tau + t$ for the first time. It is clear that $g(z_0,t)$ is defined only for the values $t = z_0 + nh$, $(n = 0,1,2, \ldots)$, so that we have, in effect, a discrete probability distribution of first passage times. It has been found that:

$$g(z_0, z_0 + nh) = \begin{cases} \exp(-\lambda z_0) & (n = 0) \\ \exp\{-\lambda(z_0 + nh)\} \times \frac{\lambda^n}{n!} z_0 (z_0 + nh)^{n-1} & (n \geqslant 1) \end{cases} \qquad (3)$$

The probability of emptiness at time $t + \tau$, not necessarily for the first time, starting with $Z(\tau) = 0$, has also been obtained as:

$$\mathrm{F}(0, \tau; 0, \tau + t) = \begin{cases} \exp(-\lambda t) & (0 \leqslant t < h) \\ \exp(-\lambda t)\{1 + \sum_{r=1}^{n} \frac{\lambda^r}{r!} (t - rh) t^{r-1}\} & (nh \leqslant t < (n+1)h) \end{cases} \qquad (4)$$

where $n = 1,2, \ldots$, and by using both (3) and (4) it is possible to write the general form of the probability $P_0(z_0, t) = \mathrm{F}(z_0, \tau; 0, \tau + t)$ of emptiness at time $t + \tau$ starting with $Z(\tau) = z_0$, as a convolution:

$$P_0(z_0, t) = \sum_{r=0}^{n} g(z_0, z_0 + rh) \mathrm{F}(0, \tau + z_0 + rh; 0, \tau + t) \qquad (5)$$

where $z_0 + nh \leqslant t < z_0 + (n + 1)h$.

These probabilities finally lead to a general solution for the process $\{Z(t)\}$. The Laplace–Stieltjes transform $\Psi(\theta, t)$ of the distribution function $F(z, t)$ already defined is found to be:

$$\Psi(\theta, t) = \exp\{[\theta + \lambda(\exp(-\theta h) - 1)]t - \theta z_0\} - \theta \int_0^t P_0(z_0, t - u) \exp\{[\theta + \lambda(\exp(-\theta h) - 1)]u\} du \qquad (6)$$

under certain general conditions, which we shall not specify here, its limit as $t \to \infty$ is easily verified to be the transform of the stationary distribution $\Phi(z)$ of equation (2). A similar result in the theory of queues, the analogies of which with the theory of storage are well known, has recently been published by Benes[6].

The work we have briefly outlined will be published in greater detail elsewhere, together with a parallel account of Moran's[3] storage problem with gamma-input. It is also proposed to present a general treatment of stochastic storage processes with inputs having certain types of infinitely divisible distributions.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Comparison of Cæsium Frequency Standards of Different Construction

Comparisons between the National Physical Laboratory standard and an 'Atomichron', by means of standard frequency transmissions[1], indicated an average difference of 4 parts in 10^{10} with a standard deviation of 4 parts in 10^{10}. Comparisons made by means of time signals in the course of a joint programme being carried out by the National Physical Laboratory and the U.S. Naval Observatory gave a larger difference, 9 parts in 10^{10}. This difference was discussed at the meeting of the Consultative Committee for the Definition of the Second at Sèvres in June 1957 and in a paper submitted by Dr. W. Markowitz to the XIIth Assembly of the International Scientific Radio Union at Boulder in August 1957. The desirability of carrying out direct comparisons in the same laboratory between the National Physical Laboratory standard and the 'Atomichrons' was emphasized at both meetings. Such comparisons have recently been made at the National Physical Laboratory, Teddington, in collaboration with the United States Army Signal Engineering Laboratories, Fort Monmouth, as the agency which initiated the project and supplied the 'Atomichrons', and the National Company Inc., of Malden, Massachusetts, as the contractor of the U.S. Army Signal Engineering Laboratories.

The atomic beam tubes of the 'Atomichrons'[2] differ in important respects from the National Physical Laboratory beam tube[3]; and the former are used with a servo mechanism to control the frequency of a quartz oscillator, whereas the latter is used as a resonator in terms of which the quartz clocks are calibrated. Tests, which will be described in detail elsewhere[4], were made to compare the frequencies of the standards as they are normally used, and then to determine the causes of the differences observed.

Two 'Atomichrons', Nos. 111 and 117, were first operated with their servo systems and in addition an experimental tube, No. 857 *X* 1, made by the National Company, was operated with the electronics and servo of No. 111. Their frequencies were compared with the National Physical Laboratory standard and with one of the quartz clocks, *Q*13, which was used merely to provide a continuous link throughout the measurements. The procedure was repeated after a number of realignments of the circuit controls of the 'Atomichrons' carried out by different observers in accordance with a prescribed procedure. The results are given in Table 1. It is of interest to note that the first measurement was made with the equipments as they arrived from the United States before a full realignment was made. The results for *Q*13 show that it can in general be used for interpolation over periods of a few days, although there is a small discontinuity between the values for March 24 and 26. The general drift in frequency is typical for this type of oscillator.

Table 1. Frequency Reproducibility after Realignment
Frequency difference: Unit 1×10^{-10}

Date 1958	'Atomichron' No. 111 − N.P.L. standard	'Atomichron' No. 117 − N.P.L. standard	Nat. Co. No. 857 *X* 1 with 111 electronics − N.P.L. standard	*Q* 13 − N.P.L. standard
March 6	3·6	3·5		230·0
,, 7	3·8	3·6		231·8
,, 10		3·3		233·5
,, 11		4·0		233·6
,, 12		3·2	4·7	234·5
,, 14		2·5	4·2	235·3
,, 17	4·1	3·5		238·2
,, 18 (a.m.)	3·7	3·7		239·4
,, 18 (p.m.)	3·6	2·7		238·1
,, 19 (a.m.)	4·3	3·3		240·2
,, 19 (p.m.)	4·0	3·2		240·0
,, 20 (a.m.)	3·9	3·1		240·7
,, 20 (p.m.)	4·5			241·4
,, 24 (a.m.)	3·5	3·4		244·7
,, 24 (p.m.)	3·6	2·8		244·8
,, 24 (p.m.)	3·8	3·3		245·5
,, 26	3·4			244·1
,, 28	3·2			245·8
April 1 (a.m.)	3·5	3·0		249·2
,, 1 (p.m.)	3·7	2·9		249·6
,, 2	3·5	3·2		250·7
Mean	3·7±0·3	3·2±0·4	4·5±0·3	

The limits are the standard deviation of a single observation.

The beam tubes were then tested as resonators with the National Physical Laboratory driving source in order to measure the combined effect of the electronics and servo. In this test it was assumed that the National Physical Laboratory electronics, which does not involve a frequency synthesizer in the driving oscillator, produced a distortion-free micro-wave signal. The symmetry of the resonance was also measured because any asymmetry is necessarily accompanied by a shift in the peak of the curve. The asymmetry and resonant frequency were measured as functions of the radio-frequency power applied to the tubes, and in the two cases in which there was a measurable change with power it would be expected that the lowest usable power would give the frequency nearest to the true value. The error with the power used in the conditions of normal operation is given in Table 2, together with the errors due to the other effects investigated. The precision of these measurements was about $\pm 2 \times 10^{-11}$, so that although the effects are small they are significant. The limits of error given in Table 2 include the estimated systematic errors.

Table 2. Beam Tubes tested as Resonators
(Unit 1×10^{-11})

Effect	Frequency error 111	117	857 *X* 1	N.P.L.
Servo and electronics	+8±4	+6±4	+20±4	0
Asymmetry	−3±7	−16±7	0±7	−10±10
Radio-frequency power	+4±2	+9±2	0±2	0±5

The measured errors due to the servo, electronics and asymmetry can be applied as corrections to the mean frequencies of Table 1 provided that the difference between the resonance frequencies determined by the d.c. and a.c. (modulation) methods is negligible compared with the errors shown in Table 2. The final results of the comparisons are then as follows:

111 − N.P.L.	$2{\cdot}2 \pm 1{\cdot}4 \times 10^{-10}$
117 − N.P.L.	$3{\cdot}2 \pm 1{\cdot}4 \times 10^{-10}$
857 *X* 1 − N.P.L.	$1{\cdot}5 \pm 1{\cdot}4 \times 10^{-10}$

The error due to the radio-frequency power could be responsible for some of the residual differences, but as it may be linked with the others and is not fully understood, it has not been applied as a correction.

In a further test, the driving source of 117 was used to excite the National Physical Laboratory beam tube. The frequency obtained was 8×10^{-11}

higher than the value obtained with the National Physical Laboratory source, indicating that some error can be attributed to the electronics alone, apart from the servo and beam tube. Additional realignment tests were made at the conclusion of the investigation, and the results are included in Table 1.

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The Annual Pole Tide

The annual variation in latitude[1] causes a disturbance in the gravitational potential with an amplitude:

$$U = a^2\Omega^2 m \sin\theta\cos\theta = 880 \sin\theta\cos\theta \text{ cm.}^2 \text{ sec.}^{-2}$$

where a is the radius and Ω the angular velocity of the Earth, and where m is the angular displacement of the pole along the meridian of a station located at co-latitude θ. For the annual term, Jeffreys[1] obtained $m \approx 0\cdot084'' = 4\cdot07 \times 10^{-7}$ radians, and the numerical value 880 follows from this. In comparison, the equilibrium tide S_a associated with the annual variation of the heliocentric distance has a potential[2]:

$$472(\tfrac{1}{3} - \cos^2\theta)\text{cm.}^2 \text{ sec.}^{-2}$$

The mean square values, $\int_0^{\pi/2} U^2 \sin\theta \, d\theta$, are equal to (321 cm.^{2} sec.$^{-2}$)^2 for the 'pole tide', and (141 cm.^{2} sec.$^{-2}$)^2 for the S_a, so that the pole tide is larger. Yet it appears to have been overlooked. This simply means that there is a larger effect from a movement, north or south, by 10 ft. than from a variation by 2 per cent of the Sun's distance.

The annual oceanic pole tide has an amplitude:

$$(1 + k - h)U/g = 0\cdot62 \sin\theta\cos\theta \text{ cm.}$$

where $k = 0\cdot29$, $h = 0\cdot59$ are the Love numbers. This is negligibly small compared to the observed tide, which has amplitude of the order of 10 cm. and is due largely to meteorological factors[3].

The disturbance in gravity due to the bodily pole tide has an amplitude:

$$\Delta g = 2(1 - \tfrac{3}{2}k + h)U/a = 3\cdot2 \sin\theta\cos\theta \text{ microgal.}$$

which will be difficult to observe. There is barely a possibility[4] of observing the difference in time kept by a pendulum clock (frequency $\sim \sqrt{g}$) and a quartz crystal clock. This time-difference has an amplitude:

$$\tfrac{1}{2}(\Delta g/g)(T/2\pi) = 0\cdot01 \text{ sec. } \sin\theta\cos\theta$$

for $T = 1$ year. The corresponding error in time-keeping for the semi-annual tide is 0·006 sec. at the equator, according to Jeffreys[5].

Thus the annual disturbance in the gravitational potential resulting from the Earth's wobble is small indeed, and worthy of note only because it exceeds the annual solar tide which is included in all text-books on the subject.

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California. May 12.

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Relative Intensities of the Oxygen Lines at 5577 A. and 6300 A. in the Night Sky

A patrol spectrograph on loan from the U.S. International Geophysical Year Committee through the Air Force Cambridge Research Center has been operating at Invercargill since August 13, 1957. This spectrograph scans a 165° strip of sky along the spectral line, the strip of sky in this case lying along the geomagnetic meridian. With exposures of the order of four to five hours on the night sky, using film with Kodak 103*a*–*F*(3) emulsion, the spectrograph has recorded the red and green lines of atomic oxygen (6300 A. and 5577 A. of OI). A preliminary analysis of 220 spectra has been carried out for the period August 13–December 31, 1957.

On some nights the 6300 A. line is considerably more intense than the 5577 A. line and on other nights the reverse is true. On many occasions it was observed that the brightness of these lines varied considerably across the sky. The relative intensity was determined by visual inspection of the film. The spectra were divided into three groups: (1) 6300 A. more intense than 5577 A., (2) 6300 A. and 5577 A. of approximately equal intensity, and (3) 6300 A. less intense than 5577 A. Each spectrum was divided into two regions, corresponding to the northern and southern sky, which were treated separately.

The relative intensity of these lines has been correlated with the magnetic K-indices from Amberley and Macquarie Island, these being the nearest magnetic observatories to the north and south of Invercargill respectively. The K-indices were averaged over the period of exposure of each spectrum.

When the relative intensity is correlated with the Macquarie Island K-index, it is found that for K equal to 0 or 1, the 5577 A. line has a high probability of being more intense than the 6300 A. line. When K equals 4 or greater, there is a high probability of the 6300 A. line being the dominant line. The heavy curves in Fig. 1 show the probability of the 5577 A. line (marked G) and the 6300 A. line (marked R) being the dominant line in the southern sky, plotted as a function of the Macquarie Island K-index. The thin curves give similar information about the spectra of the northern sky. It can be seen that there is a consistent tendency for the red to be the dominant line more often in the southern sky than in the northern sky.

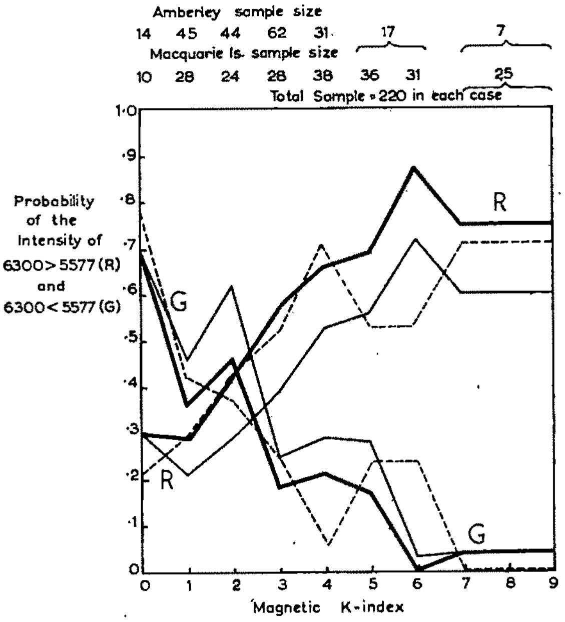

Fig. 1. Relative intensity of the OI lines at 6300 A. and 5577 A. as a function of K-index. The heavy curves are the relative intensities for the southern sky plotted as a function of the K-index at Macquarie Island, the thin curves are the relative intensities for the northern sky as a function of Macquarie Island K-index and the dotted curves the relative intensities for the northern sky plotted as a function of the K-index at Amberley. The sample sizes for Amberley and Macquarie Island are given at the top of the figure

When the northern sky intensities are correlated with the magnetic K-index from Amberley (north of Invercargill), as shown by the dotted lines, then the distribution of probability for the northern sky curve is shifted into a position nearly coincident with the southern sky curve, which is plotted against the Macquarie Island K-index. The agreement between these curves (the heavy and dashed curves) over the range of K from 1 to 4 where the samples are large suggests that the relative intensity is a function of the local K-index.

About 20 per cent of the spectra fall in the group of equal intensity, which has a probability approximately independent of K-index. Of the 220 spectra obtained, auroræ were recognized as being present in about seventy cases, either from the presence of nitrogen bands in the spectra or from direct photography.

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A Comparison of Radio Echoes from the Aurora Australis and Aurora Borealis

The problem of the relation of the occurrence of auroræ in the northern and southern hemispheres is one of considerable importance to the theories of auroral formation. Hitherto, the assessment of these occurrences has been handicapped by the difficulties of the collection of simultaneous visual observations in the arctic and antarctic regions, and by the fact that in any event auroræ occur on at least 75 per cent of nights in the zones of maximum activity in which the visual observations tend to be concentrated. So far the evidence for the simultaneity of the occurrences has been largely of a statistical nature[1]. The Royal Society's Expedition to Halley Bay has provided an opportunity for a simultaneous study of the aurora australis and borealis by the radio-echo technique, and a preliminary account of the results is given in this communication.

The continuous radio-echo observations of the aurora australis have been made since May 1957 at Halley Bay, Antarctica (long. 75·5° S., lat. 26·6° W.), using a wave-length of 4 metres. The apparatus has a rotating aerial system and in principle is identical with one which has been in use at Jodrell Bank (long. 53·2° N., lat. 2·3° W.). Full details of the equipment are given in the *I.G.Y. Annals*[2]. Preliminary results on the occurrence of auroral echoes for the period May–October 1957 have been compared with the Jodrell Bank results for the same period.

Echoes from the aurora australis have been detected at Halley Bay on 134 out of 164 days of observation during the period, whereas on only 13 days were echoes from the aurora borealis obtained at Jodrell Bank. Considered on an hourly basis, observations at Halley Bay were made for 93 per cent of the time, and echoes were present for 26 per cent of the observing time, compared with 2 per cent of the time at Jodrell Bank. A study of the echo geometry at both locations shows that the echoes are obtained from the region where the line of sight is normal to the local magnetic field at a height of about 110 km. rather than from along a line of geomagnetic latitude as originally proposed by Bullough and Kaiser[3]. From Halley Bay the locus of specular reflecting points crosses the southern region of maximum visual auroral activity as given by Vestine and Snyder[4], whereas for Jodrell Bank the locus of reflecting points lies about 9° south of the northern zone of maximum auroral frequency. The disparity in rates of occurrence is therefore to be expected and is, in fact, a fortunate circumstance when considering the simultaneity of occurrence, since only the occasional auroræ coinciding with moderate to great magnetic storms are detected at Jodrell Bank.

The relation between these widespread northern auroræ and the Halley Bay results is shown in Fig. 1. The Halley Bay results show a close correlation between the number of hours a day containing echoes (irrespective of duration or amplitude) and the corresponding daily sum of the planetary magnetic K index, K_p. It can be seen that the world-wide

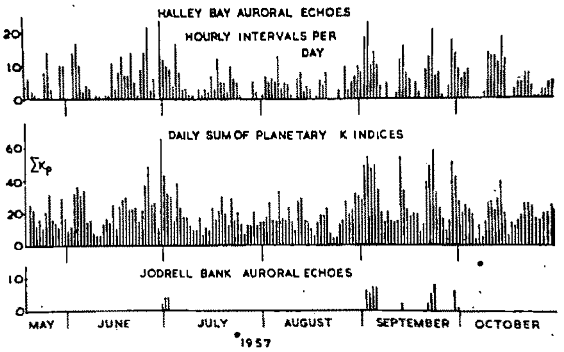

Fig. 1. Number of hourly intervals a day of auroral radio echoes detected at Halley Bay and Jodrell Bank compared with the daily sum of the planetary K index, K_p

magnetic activity maintains a strong control over the occurrence of echoes at Halley Bay over the whole range from quiet to severely disturbed conditions.

On almost all the occasions when ΣK_p exceeded about 40, echoes were obtained from the aurora borealis at Jodrell Bank, and these events coincided with the high peaks in the echo activity at Halley Bay from the aurora australis. It therefore seems reasonable to conclude that the great auroræ of the northern hemisphere are accompanied simultaneously by greatly enhanced activity of the aurora australis. It is hoped to make a more detailed study of the time correlations when the full results from Halley Bay become available.

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A Simple Technique for the Calibration of the Wave-length Scale of Spectrophotometers

IT is often essential to test the calibration, setting and working of either old or new spectrophotometers. Generally, this is carried out by the standard plastic, gelatine or glass filters supplied with the instruments. Standard solutions may also be used. We were recently faced with such a problem, but found that no solid standard filters were immediately available or easily obtainable. Further, calibration and standardization with solutions is always associated with numerous difficulties of purity of chemicals and solvents and the actual preparation of standard solutions. It is well known that even chemicals labelled 'chemically pure' are sometimes contaminated. Further, departures from Beer's law and the exact range of wave-length in the so-called monochromatic beam used are also common sources of error. The problem is often complicated by systematic errors such as dichroism, colloidal particles or temperature effects.

An attempt was therefore made to find an easy and reliable method of calibration relatively free from error. This has been achieved by taking advantage of the transmittancy curves of solutions of acid-base indicators such as methyl orange. It is known[1] that the transmittancy curves for the different *p*H values for any particular indicator all intersect at a point known as the isosbestic point, which has a value of 469 mμ for methyl orange. It is clear, therefore, that if an acidic and a basic solution made from equal amounts of the same stock solution of methyl orange are kept in two cells and the difference in their transmittancy observed at different wave-lengths, then ΔT_s would be zero at only one wave-length, namely, 469 mμ. ΔT_s can be determined by simply sliding the two cells containing the acidic and the basic solutions of the indicator, one by one, in the path of the beam. As this method is very similar to a null method, all the disturbing minor factors remain constant and balance out without affecting the accuracy of the calibration.

An incidental advantage in the method is that the procedure involves the determination of a point of intersection; this is normally more precise than determination of a maximum or minimum absorbency. In practical determinations, the equality of absorbency is far easier to establish than determination of the wave-length corresponding to a maximum or minimum. We have calibrated the spectrophotometer by this method and measured the isosbestic point of bromocresol green and have been able to reproduce the value reported in the literature. It is, however, necessary to add here that there must be no impurity in the indicator, the absorbency of which depends on *p*H. Although we have used methyl orange and bromocresol green, many other indicators would also serve the purpose.

Table 1

Indicator	*p*H range	Isosbestic point (mμ)
Methyl orange	2·6–5·0	469[1]
Bromocresol green	3·4–5·2	509[1]
Neutral red	5·6–8·4	480[2]
Thymol blue (acid)	1·2–3·4	485[2]
Thymol blue (alkaline)	7·4–10·2	500[2]
Phenol red	6·2–9·2	481[2]
p-Nitrophenol	5·0–9·0	350[3]

The wave-length values for the isosbestic points of a few indicators are given in Table 1. In addition, the transmittancy curves for bromophenol blue (*p*H range 2·4–5·6), methyl red (*p*H 3·4–7·0), bromocresol purple (*p*H 4·8–7·6), cresol red (*p*H 6·8–9·6) and bromothymol blue (*p*H 5·8–8·4) are given in the literature[2], from which the exact wave-length values for their isosbestic points may be ascertained.

We are not aware of any previous reports of the use of this principle for accurate calibration.

We wish to thank Dr. K. S. G. Doss, director of the Central Electrochemical Research Institute, for his useful suggestions.

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Photovoltaic Pile

IN a previous communication[1], a retinal type of photovoltaic cell is described in which many inert 'point' electrodes are placed in a parallel mosaic arrangement in a small volume of photo-active solution. To indicate that each electrode is a photoreceptor, a separate d.c. amplifier is required. An attempt was then made to construct a multiple-point photovoltaic cell in which all the individual electrodes are connected in series, as shown in Fig. 1. One set of electrodes is kept dark with tape while the other is irradiated as in a thermopile. Only one amplifier[1] is of course needed for this cell. As more light- and dark-electrode pairs are added in series, larger photopotentials are eventually generated, but at a much slower rate than with the individual point electrodes in parallel; also, with certain photo-active solutes,

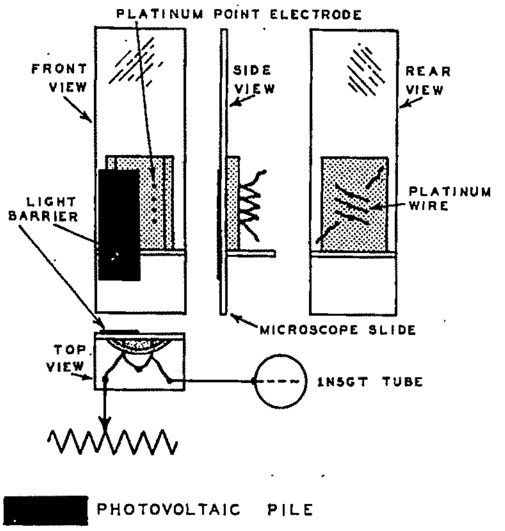

Fig. 1

the transient photo-inductive effect[2] is greatly enhanced, probably because of the presence of an oxygen-coordinated intermediate or other electron 'source' between, say, benzoin and benzil.

In Nature, perhaps the only analogy to this type of photovoltaic cell are the electric fish (electric eel, electric ray with its flat head, and electric catfish) which inhabit the upper shallow waters, but the role of light is questionable in each individual case.

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Nature of Betanin, the Pigment of Red Beet

It has been generally supposed that the major red pigment of the root tissue of *Beta vulgaris* is composed of an anthocyanin nucleus coupled in some way with one or more amino-acids[1-4]. The other pigments, both red and yellow, are presumably very similar, with only minor variations[5]. The extreme instability of the compound and the difficulty with which it is obtained in the pure state demonstrate that these suppositions are highly speculative, at best.

In considering the previous investigations of betanin, it became obvious that certain important observations have been overlooked or misinterpreted. The most striking characteristic of betanin is its peculiar absorption spectrum. The partially purified preparations previously investigated have been reported to absorb strongly at wave-lengths shorter than 350 mμ. The pure crystalline pigment recently obtained by Wyler and Dreiding[6] exhibits only slight absorption in the region of 235–400 mμ. We have confirmed these observations by a simplified purification procedure based on an initial adsorption on a 'Magnesol-Hyflo Super Cel' column (1 : 1) followed by elution with water, precipitation as the lead salt, and conversion into the free pigment by the usual procedures[7]. Our purified preparations are characterized also by negligible absorption in the region 235–400 mμ. In this respect betanin differs markedly from any of the polyhydroxy flavylium salts. Its absorption spectrum in the near ultra-violet region definitely shows the absence of aromaticity. This is confirmed by infra-red absorption spectra recently obtained, which show conspicuous absence of aromatic C–H stretching absorption at 3·3 μ. There is a sharply defined peak at 3·0μ which may be due to the presence of an O–H or N–H group in the compound.

Crystallized betanin and purified amorphous preparations contain nitrogen in amounts varying from 5 to 8 per cent[1,4-7]. Only one amorphous preparation practically nitrogen-free was obtained[3], and the absence of nitrogen in this preparation might be explained as a possible decomposition on the ion-exchange resin used[4]. We have not been able to reduce the nitrogen content of betanin by treatment with anion-exchange resins. The nitrogen present in betanin can be assumed to be ring nitrogen and the nitrogenous constituent to be either very weakly basic or possibly acidic[7]. On the basis of this and other evidence which has been overlooked or misinterpreted, we were drawn to the conclusion that betanin contains a pyrrole nucleus. Actually Ainley and Robinson[1] reported that on alkali fusion betanin yields a colourless compound giving a positive Ehrlich test. This observation we have confirmed and extended recently.

The conclusion that betanin contains a pyrrole nucleus is supported by the spectral characteristics and all the known chemical and physical properties of the pigment. The most important evidence lies in the fact that alkali fusion of betanin yields a colourless compound giving a positive Ehrlich's test. We have been able to purify this by precipitation as the mercuric salt, followed by decomposition by hydrogen sulphide, but its identification is not yet complete. Similar breakdown products giving a positive Ehrlich test can be obtained from fusion of the second major red pigment and also from the major yellow pigment. We have also identified carbon dioxide and methylamine as fusion products from all three. Ainley and Robinson (ref. 1, p. 449) reported the evolution of a base with methylamine-like odour under these conditions.

The yellow pigments present are not only similar, but also are probably precursors of the red and purple pigments. We have noticed on several occasions that certain yellow pigments (purified on a 'Magnesol' column) when allowed to stand overnight at room temperature become red-orange in colour. These preparations are then separated on an identical 'Magnesol' column into a yellow and a purple band. This explains the uncertainty of Aronoff and Aronoff[8] as to the exact number of pigments present. We have not determined whether this is due to oxidation, but it is perhaps significant that the same purified yellow pigments react with *ortho*- or *para*-substituted aromatic amines in acid solution at room temperature, yielding pink to purple compounds.

Betanin itself is easily reduced to a yellow pigment by metallic zinc in acid solution. This reduction product is re-oxidized to red-purple by exposure to oxygen at room temperature for a few hours. Dilute hydrogen peroxide hastens the re-oxidation.

Since some of the differences reported in the isolation and characterization of betanin were probably due to genetic and ecological variation in the beet roots investigated[8], we have examined several selected strains of beets grown under the same climatic and soil conditions. These differed mainly in yield of betanin and in the readiness with which the crude betanin could be purified.

We have used absorption in the ultra-violet as a criterion for purity and have found that pigment from the variety Green Top Bunching is most easily freed from impurities absorbing in the ultra-violet region. Indeed, pigment prepared from Green Top Bunching by the method of Pucher, Curtis and Vickery[7] is practically free from ultra-violet absorption.

On the basis of the above considerations it is concluded that betanin is a pyrrole pigment and not a "nitrogenous anthocyanin". This does not preclude the presence of "nitrogenous anthocyanins" in other plant species[9].

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The interesting communication of R. G. Peterson and M. A. Joslyn on this subject calls for some comment. In the first place, the term "nitrogenous anthocyanin" is used partly chemically (nitrogenous) and largely botanically (anthocyanin) to denote an obviously related group of water-soluble bluish-red colouring matters, such as those of *Beta*, *Atriplex*, *Celosia*, and certain Cactaceae. The only evidence favouring some form of amino-flavylium salt structure, which was the basis of a working hypothesis, was the colour and some other properties of synthetic amino-flavylium salts containing hydroxyl and methoxyl groups[1]. There was a certain resemblance between the absorption spectra in the visible region of betanin and 4′-amino-3 : 7-dihydroxyflavylium chloride. However, no phenolic degradation products could be obtained from betanidin[2]. We have always recognized that the relation to the flavylium group was unconfirmed and a purely speculative hypothesis. The evidence in favour of a pyrroloid constitution is not much stronger.

The argument from spectra is double-edged and inconclusive in the absence of appropriate models. Thus hydroxyl- and amino-substituents tend to erase fine structure in the visible region and ultra-violet spectra, while it is hard to predict with any confidence the infra-red band positions for likely structures that could explain the colour of these pigments. It is true that $C_{20}H_{23}O_7N_2Cl$[2] could be $C_9H_9N_2Cl$ (dipyrromethene salt) $+C_6H_{10}O_5$ (sugar fragment, perhaps as in barbaloin) $+C_5H_4O_2$ (many possible interpretations), but bougainvillæidin is a member of this group of pigments with about C_{22}/N in the molecule[3].

Although it is possible that there are two (or more) types of nitrogenous anthocyans; and although a pendent C_{20} group cannot be excluded, the more natural view is that the essential content of the chromophore-cum-auxochrome may include only one nitrogen atom. Some years ago my colleague Dr. J. W. Barltrop suggested an attractive possibility for betanin, but this also demanded N_2, and bougainvillæidin seemed to be an obstacle at that time.

The solution of the problem awaits further work, especially some revealing degradation.

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Molecular Changes in Exchange Labelling with Tritium

Wilzbach[1] has recently described a convenient method for labelling organic compounds involving their exposure to tritium gas; but both he and others[2,3] found that appreciable amounts of the exchanged radioactivity appeared in traces of highly tritiated contaminants as well as in labile positions. We have applied this method to the labelling of 1 : 6-dihydroxyhexœstrol, an œstrogen analogue[4], and similarly have found that impurities contain the major part of the incorporated non-labile tritium.

These results could be explained by a preferential exchange of tritium for the hydrogen atoms of trace amounts of impurity present in the starting material. Alternatively, highly radioactive by-products might have been formed from chemically pure material by degradation in the course of the exchange reaction.

In order to differentiate between these two possibilities, dihydroxyhexœstrol (10 mgm.) was exposed to tritium gas (200 mc.) for 14 days. The product, after removal of labile tritium, was washed three times with ether; more than 60 per cent of the radioactivity was hereby removed, although dihydroxyhexœstrol itself is virtually insoluble in this solvent. Finally, crystallization of the ether-washed material from aqueous ethanol gave a product which retained its specific radioactivity on further crystallization. On re-exposure of the purified material to tritium gas, comparable amounts of radioactive impurities soluble in ether were again formed. These radioactive contaminants are thus produced by changes in a chemically pure organic compound when it is exposed to tritium gas. Identification of the by-products is now being attempted.

These results further demonstrate the necessity for rigorous purification of radioactive compounds prepared by this useful labelling method.

We are indebted to Mr. W. Lawson, of the Middlesex Hospital Medical School, for a generous gift of dihydroxyhexœstrol.

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Chemical Reactions initiated by Ultrasonic Waves

I HAVE been engaged in the study of a number of reactions in solution caused by ultrasonic waves.

Sono-chemical decomposition of organic halides. Under the influence of ultrasonic waves aqueous solutions of chloroform, carbon tetrachloride, dichloro- and diiodo-methane, dichloro- and dibromoethane, and ethyl chloride, bromide and iodide have been found to liberate halogens[1] in both the ionic and the molecular states (tested by silver nitrate solution, potassium iodide and starch indicator). Five of these have been studied in detail and the results are summarized here (compare refs. 2–7).

(1) Aqueous solutions of dichloromethane, chloroform, carbon tetrachloride, dichloroethane and ethyl bromide subjected to ultrasonic waves (1–2 Mc./s., 225 watts electrical input to the transducer) liberate halogens, simultaneously producing polymerized solids. None of them, except chloroform, decomposes in the pure state.

(2) In all five cases only a part of the total halogen is liberated and does not seem to increase much with long exposures. The liberation of halogens increases with dilution.

(3) A considerable bulk effect is observed, probably due to the direct load of the liquid on the transducer.

(4) Organic liquids such as alcohol and acetone retard the reaction, and beyond a certain concentration the reactions stop altogether.

(5) Ultrasonic intensity influences the reaction; at higher power output the reactions are accelerated.

(6) The decompositions are of zero order and in four cases (CH_2Cl_2 not tried) the reactions proceed faster at lower temperatures.

(7) The primary sono-chemical reactions postulated are:

$$\mathrm{H.OH} \rightarrow \mathrm{H} + \mathrm{OH}$$

consuming 118 kcal.

and

$$Alk\text{–}X \rightarrow Alk + X$$

consuming 68 kcal. for C—Cl and 54·5 kcal. for C—Br

where X is a halogen atom.

These reactions are supposed to be followed by hydrolysis and polymerization.

Sono-chemical decomposition of organic sulphides. The bond-strength between carbon and sulphur is 54·5 kcal., which is approximately equal to that between carbon and bromine in organic aliphatic halides. It was believed, therefore, that organic sulphur compounds would decompose in the same way as organic halides, liberating sulphur. The simplest organic sulphide, namely, carbon disulphide, was exposed to ultrasonic waves in the pure state as well as in aqueous solutions. In the pure state there was no detectable liberation of sulphur, whereas in aqueous solution a brown-coloured colloidal sol which was very stable was obtained. Similarly, with aqueous solutions of ethyl disulphide a white-coloured colloidal sol, which was very stable, was obtained. It was analysed qualitatively and the colloidal sulphur particles were observed to be of a different size-range from those from carbon disulphide. The brown sol treated with ammonia gave a brown colour, and with sulphuric acid a pink colour. When the solid obtained by centrifuging was treated with various organic solvents, a black residue was obtained which was suspected to be carbon.

On this basis the following mechanism for the decomposition of carbon disulphide is suggested:

$$\begin{array}{lcl}
CS_2 & \rightarrow & (CS) + S \\
n(CS) & \rightarrow & (CS)_n \\
(CS) & \rightarrow & C + S \\
CS_2 + H_2O & \rightarrow & COS + H_2S \\
COS + H_2O & \rightarrow & CO_2 + H_2S
\end{array}$$

Inorganic reactions initiated by ultrasonic waves. I exposed redistilled water to ultrasonic waves and observed a change in conductivity (after $1\frac{1}{2}$ hr. exposure, from 4×10^{-6} to $1{\cdot}15 \times 10^{-4}$ ohm^{-1}cm.$^{-1}$), but no conclusive reactions due to the presence of hydrogen peroxide in the free state were obtained. A very dilute acidic solution of potassium permanganate was decolorized, but a very dilute acidic solution of potassium dichromate covered with a layer of ether showed no change in colour. When a slightly higher concentration of potassium permanganate was used it gave a sol at shorter periods of exposure, and after long exposure gave a brown precipitate, probably an oxide of manganese. A titanous solution exposed to ultrasonic waves was oxidized to the titanic state, losing its violet colour, but a cerous solution did not turn orange, indicating that it had not been oxidized to the ceric form. A ferrous solution was converted to the ferric state, identified by the usual potassium thiocyanate and potassium ferricyanide tests.

The experimental work reported here was carried out in the Chemical Laboratories of the University of Allahabad.

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Chemistry and Clay Mineralogy of a Soil Sample from Antarctica

A SAMPLE of soil, scraped up by Mr. A. S. Helm from Scott Base, McMurdo Sound, has been analysed by this laboratory. The material contained many well-rounded blue-grey stones of basaltic and arenaceous origin, the majority being basaltic. It was apparently derived from the basaltic rocks which outcrop in the area and mixed with material from sedimentary sources in the vicinity. No humus was apparent to the eye but the sample contained a small piece of moss as well as some bacteria (J. D. Stout, personal communication) and is thus justifiably regarded as a soil. Of the material collected, 98·6 per cent was less than 25 mm. in diameter and 64 per cent less than 2 mm. Only 2·6 per cent was less than 0·066 mm. and less than 1 per cent of clay was present.

The high pH value (1 : 2·5 water suspension) is apparently caused by the presence of calcium car-

Table 1. CHEMICAL ANALYSIS (RESULTS ON OVEN-DRY BASIS)

pH	Phosphate soluble in 1 per cent citric acid (mgm. per cent)	C (per cent)	N (per cent)	C/N	Cation-exchange capacity (m.equiv. per cent)	Exchangeable cations (m.equiv. per cent) Ca	Mg	K	Na	CaCO$_3$ (per cent)	Total soluble salts (m.equiv. per cent)
8·5	54	0·31	0·022	14	22·6	4·7	3·6	6·5	7·4	0·13	1·3

bonate in the form of fine shell fragments. The content of phosphate soluble in 1 per cent citric acid is very high and entirely inorganic in nature. Both carbon and nitrogen figures are low and the resulting low carbon/nitrogen ratio suggests that the organic matter has undergone humification processes.

Although this soil contains very little of either clay or organic colloids, the cation-exchange capacity (neutral normal ammonium acetate procedure) is high, and Fig. 1 shows that the fine sand fractions have very high capacities and that moderately high capacities persist into the coarser fractions. These high capacities could result either from the presence of palagonitic material in the sample or to the cation-retaining powers of fractured, unleached mineral surfaces. Fig. 1 shows also that distillation with sodium hydroxide drives off more ammonium ions than does magnesium oxide; this difference, which is most apparent in the coarser fractions, seems similar to the phenomenon described by Barshad[1] which he termed "ammonium fixation".

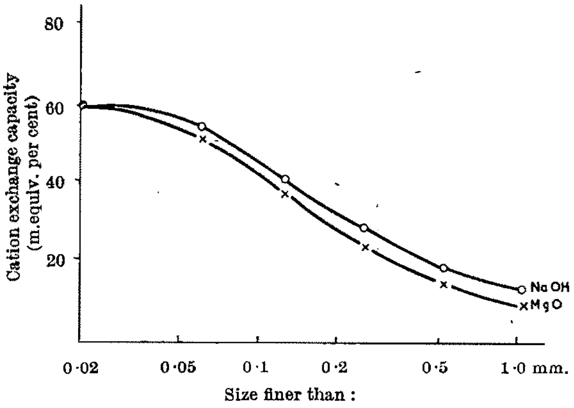

Fig. 1. Cation exchange capacity of various size fractions

The predominant feature of the individual exchangeable cations is the very high content of potassium and sodium. Total analysis showed that this material contained quite normal amounts of potassium and sodium for basic rocks, and the high exchangeable contents suggest a lack of leaching. Although free lime is present, the calcium forms only a small part of the exchangeable cations and this fact, together with the presence of water-soluble salts (mainly sodium bicarbonate and chloride), indicates that the movement of water through this soil has been very small in amount.

Clay of less than 2μ equivalent diameter was separated from the soil using sodium hexametaphosphate as dispersing agent. It was washed free of sodium ions and examined by X-ray diffraction using the dispersed sample, a potassium-saturated sample, and a magnesium-saturated, glycerol-saturated sample.

Dioctahedral mica was the main crystalline mineral present in the clay. Inter-stratified swelling and non-swelling micaceous minerals, quartz, feldspar, and a little kaolin were also found. An electron micrograph showed that some amorphous material was present.

It is unlikely that the dioctahedral mica or the quartz is derived from the basaltic stones which make up most of the material. They may have been derived from the sandstone either in place or where the sandstone forms the basement rock. If they have been derived in place they show that the weathering which has produced the material was preponderantly physical. Mica, quartz and feldspar are present in the sandstone, and have probably reached clay size by the physical process of comminution. The swelling micaceous minerals and the kaolin, which together comprise only a small proportion of the small amount of clay, are the only recognizable catamorphic products, and they may have been formed by processes occurring before the present soil-formation stages. If they were formed elsewhere, they indicate that the amount of clay formed in the present cycle of weathering and soil-formation is zero, and again indicate that physical weathering is preponderant and chemical weathering negligible.

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Different Phases of Tectonic Deformation in the Rhinns of Galloway

IN the overthrust Caledonian metamorphics of Swedish Lapland there are traces of at least three main phases of deformation. This has been proved by graphic-statistical studies on the tectonics of a sequence of six small areas[1,2]. Each of the phases is distinguished by certain directions of main transport that are constant for all the areas. There is a fair amount of evidence of several kinds to establish the age-relations of the phases. First, there were transport directions toward east-south-east, then toward the south-south-east, then toward the east (and/or south ?).

The exceptionally well-exposed folded Ordovician and Silurian greywackes and shales of the Rhinns of Galloway were chosen as a test field for the hypothesis that phases of deformation with different transport directions may have affected less metamorphic strips of the Caledonides as well. The Rhinns of Galloway coast affords a classic example of the current idea of the north-western belt of the Southern Uplands of Scotland as a fan structure striking north-east – south-west, with roughly isoclinal folds, the limbs of which generally dip toward the central axis of the structural complex[3].

Tectonic data were collected from Broadsea Bay and southward, at eighteen fairly evenly spaced localities, each representing 200–1,000 m. of the coast. The orientations of 1,600 bedding-planes and 2,100 joints were recorded as exactly as possible. The lines of intersection (β) of the bedding-planes tend to represent fold axes. The β intersection was constructed graphically for each two succeeding bedding-planes. All β intersections were brought into synoptic diagrams, one for a north sub-area (the coast section Broadsea Bay–Morroch Bay), and one for a south sub-area (the south part of the Rhinns, including Portayew in the north). Two other synoptic diagrams were prepared for the normals of all joints recorded in each of the two sub-areas. The axes were plotted on a Schmidt net that is regarded as the lower hemisphere. The general axial plunge is 10–30° toward the north-east. The joints tend to be *ac* joints, that is to say, normal to the fold axes. There are persistent concentrations of nearly horizontal axes about N. 75° E. and N. 47° E. Axes belonging to these groups occur in both sub-areas and at different localities. Both systems frequently are met with at the same locality. For this reason, the systems cannot be due to differences in local tectonic setting. The structures striking N. 47° E. as a rule are almost isoclinal folds that are overturned toward the north-west. The N. 75° E. strikes are associated with some shattering of the beds, and important thrust zones dipping northward. The most impressive of these thrusts outcrops in the northern part of Cairngarroch Bay. Other thrusts are just north of Clanyard Bay. Deformations belonging to this group affect structures of the first group. There is thus evidence of at least two important post-Llandoverian phases of deformation in this part of the Uplands, one phase with transport mainly toward N. 43° W., and another, later, with transport mainly toward S. 15° E. The former phase has determined the main regional strike; the latter has converted the area of greywacke beds, dipping to the south-east, into a fan structure. It would be interesting to discover whether the same deformations can be traced farther to the north-east, along the strike of the Uplands.

Some details of the synoptic diagrams must at present be left without explanation. However, some steeply plunging fold axes of the north sub-area are largely derived from Morroch Bay, where incompetent shales have been squeezed in the core of an anticlinal structure of greywackes and split up into lenticles. These lenticles could have slipped past one another laterally, in adjustment to the squeezing. The folds seem to represent $B \perp B'$ of Sander[4].

It is obvious that with tectonites like these, joints can help to answer several questions.

A more complete account of this investigation is being prepared.

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Pancrinogen: a New Zymogen of Proteolytic Enzyme from Beef Pancreas

THREE zymogens of proteolytic enzyme in pancreas (two chymotrypsinogens and trypsinogen) are known at present. In this communication, we report the occurrence of another inactive precursor of proteolytic enzyme in beef pancreas.

Fresh beef pancreas was treated according to the method of Kunitz and Northrop[1], up to the separation of chymotrypsinogens and trypsinogen at 62 per cent saturation with ammonium sulphate (*p*H 4·2). Then the mother liquor was brought to 75 per cent saturation with solid ammonium sulphate. The resulting precipitate was collected by centrifugation and dissolved in one and a half volumes of ice-water (*p*H 4·2). To each 100 ml. of the solution 22·3 gm. of solid ammonium sulphate was added and the precipitate was centrifuged off. The supernatant was dialysed against 0·2 *M* solution of potassium chloride, previously adjusted with acetic acid to *p*H 4·2. The dialysed solution contained the bulk of the new zymogen. As all operations were carried out at *p*H 4·2 and 5° C., the possibility of bacterial activity was eliminated.

The partially purified zymogen did not show any detectable proteolytic activity toward gelatin or casein. At *p*H 8·0, the zymogen was autocatalytically transformed to active enzyme (Fig. 1). The activation of the zymogen was also induced by the addition of a trace amount of pancrin, which was prepared from a commercial porcine pancreatin by Grant's method[2]. Especially purified pancrin from beef pancreas, which was completely free from trypsin and chymotrypsin, also catalysed the activation of the zymogen at 10° C. for 32 hr. or at 37° C. for 1 hr. The latter condition eliminates the possibility of bacterial activity. It required more than 72 hr. for full activation of the zymogen in 0·2 *M* phosphate buffer, *p*H 8·0, at 10° C. without the addition of pancrin, and no activation was observed at *p*H 4·6, even in the presence of added pancrin. The zymogen

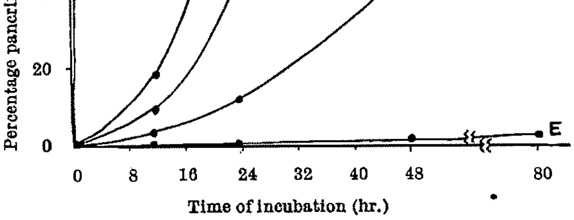

Fig. 1. Activation of pancrinogen: determination of proteolytic activity being carried out by Northrop's method (ref. 3) with 5 per cent gelatin in 0·2 *M* phosphate buffer of *p*H 8·0 at 37° C. for 15 min. Curve *A*, pancrin from beef pancreas in phosphate buffer, *p*H 8·0 at 10° C.; *B*, pancrin from porcine pancreatin, *p*H 8·0, 10° C.; *C*, autocatalytically, *p*H 8·0, 10° C.; *D*, pancrin from beef pancreas, *p*H 8·0, 37° C.; *E*, pancrin from beef pancreas, *p*H 4·6, 10° C.

was not activated by commercial crystalline trypsin during the incubation of 1 hr. at 37° C.

The active enzyme obtained from the zymogen is identical with the 'pancrin' of Grant.

These results indicate the occurrence of a new zymogen of proteolytic enzyme, which we propose to call 'pancrinogen'. Full details of this work and related problems will be published elsewhere.

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Isolation of 16β-Hydroxyœstrone from the Urine of Pregnant Women

HAVING been informed that we had succeeded in isolating 16β-hydroxyœstrone from the urine of pregnant women, Dr. T. F. Gallagher of the Sloan-Kettering Institute, New York, most courteously suggested to us that we should publish a preliminary account of our work simultaneously with his own announcement of the detection of the same compound by reverse isotope dilution in the urine of a human subject after the administration of œstradiol-17β-16-^{14}C (succeeding communication). The completion of our own work would have been delayed by many months if Dr. Gallagher had not provided us, before publication, with details of his method[1] for synthesizing 16β-hydroxyœstrone from œstrone *via* the enol diacetate of the latter. It is a pleasure to acknowledge his generous co-operation.

Pooled late-pregnancy urine (200 l.) was hydrolysed enzymically as previously described[2], extracted with ether and the extract washed with an aqueous solution of sodium bicarbonate and with water. The ketonic fraction of this material was obtained by reaction at room temperature in ethanolic acetic acid with Girard's reagent *T*. A concentrate containing the ring *D* α-ketolic œstrogen derivatives was obtained by subjecting this ketonic fraction to chromatography on celite columns using the solvent system 70 per cent (v/v) methanol in water/20 per cent (v/v) *n*-hexane in benzene. This concentrate was then subjected to chromatography on a large number of sheets of paper using the system formamide/chloroform. The material having the same mobility in this system as that of authentic 16β-hydroxyœstrone was eluted and further purified by rechromatography on paper in the same system. By this means 6·2 mgm. of a semi-crystalline product was obtained which was contaminated with a yellow oil.

This material was acetylated. After purification by chromatography on an alumina column and crystallization from methanol, 2·1 mgm. of a product melting at 138–141° C. were obtained. The mixed melting point with authentic 16β-hydroxyœstrone diacetate (melting point 139–141° C.) was 139–141° C., and the infra-red spectra of the two acetates (kindly determined by Dr. R. Norman Jones, National Research Council, Ottawa) were identical.

The isolation of 16β-hydroxyœstrone from the urine of pregnant women and the demonstration by Gallagher *et al.* that it is formed metabolically from administered œstradiol-17β provide support for the view[2–4] that 16α-hydroxyœstrone and 16β-hydroxyœstrone are the intermediates in the metabolic 'hydration' of œstrone to œstriol and 16-*epi*-œstriol respectively.

In the course of the same work we have also isolated 16-oxoœstradiol-17β (as its acetate). So far as could be determined, the latter compound could not have been formed as an artefact from either 16α-hydroxyœstrone or 16β-hydroxyœstrone by the methods employed in its isolation. The view previously expressed[3] that extracts of pregnancy urine contain no 16-oxoœstradiol-17β other than that which is formed artefactually during the isolation process is now seen to have been incorrect, and the criticisms based on this view of the work of Levitz, Spitzer and Twombly[5] are now unreservedly withdrawn.

Full details of this work will be published elsewhere.

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16β-Hydroxyœstrone, a Metabolite of Œstradiol in Man

THE *in vivo* metabolism of œstradiol-17β leads to the formation of ring *D* ketols with a hydroxyl group at C_{16}. These compounds are of interest because they may be either intermediates in the further transformation of œstrone or end products formed from the oxidation of ring *D* glycols. 16α-Hydroxyœstrone has been isolated from the urine of pregnant women by Marrian, Watson and Panattoni[1]. This communication reports the identification of the recently synthesized 16β-hydroxyœstrone[2] as a metabolite of œstradiol-17β in man. The product is formally related to the œstrogen metabolite $\Delta^{1,3,5(10)}$-œstratriene-3,16β,17β-triol[3].

Œstradiol-17β-16-^{14}C (approximately 0·5 mgm. containing a total of $1 \cdot 5 \times 10^6$ c.p.m.) was administered intravenously to a woman with cancer of the breast. The urine collected for five days after this dose was treated with β-glucuronidase, extracted with ether, and a crude phenolic plus neutral fraction was obtained after washing with 9 per cent sodium bicarbonate solution. (β-Glucuronidase, known as 'Ketodase', was obtained from the Warner–Chilcott Laboratories, a division of Warner–Lambert Pharmaceutical Company, New York.) A portion of this extract containing 40,000 c.p.m. was subjected to chromatography on papers 4 ft. long in the solvent system toluene/*iso*octane (3 : 1) as the moving phase and methanol/water (4 : 1) as the stationary phase. In this way the total ketol fraction was separated from the less polar œstradiol, œstrone and 2-methoxyœstrone and from the more polar epiœstriol (3, 16β, 17β) and œstriol (3, 16α, 17β). Appropriate standards were chromatographed simultaneously and detected with the ferric chloride – potassium ferricyanide reagent; areas containing radioactive œstrogen metabolites were located with a strip counter. The separated ketol fraction, after elution from the paper, was resubjected to chromatography in the same solvent system or with formamide and chloroform. In both systems a broad band of radioactivity was present in the area of 16α-hydroxyœstrone and 16-ketoœstradiol-17β which moved very close to each other; it was not possible to achieve a clean separation of these two compounds. However, 16β-hydroxyœstrone travelled more slowly and a distinct separation of this compound from the other two ketols was possible. A peak of radioactivity in the ketol area moved with the 16β-hydroxyœstrone standard. This latter area was eluted, mixed with a pure sample of 16β-hydroxyœstrone and resubjected to chromatography in the toluene/*iso*octane : methanol/water system. There was no separation of the radioactivity from the carrier compound. Repetitions of this experiment yielded sufficient material for reverse isotopic dilution by recrystallization to constant specific activity. The product, as it was removed from the papers, contained 57 c.p.m. per mgm., and successive recrystallizations gave values of 32, 22, 26, 22, 21 c.p.m. per mgm. It should be noted that while the final specific activity of the compound was low, the total amount of radioactivity taken for isolation was small and it was necessary to add sufficient inactive material to obtain five successive recrystallizations.

From the amount of radioactivity present in the various areas of the chromatogram, it was estimated that the total ketol fraction contained about 10 per cent of the radioactivity in the urine extract. 16β-Hydroxyœstrone was estimated to be one-third of the ketol fraction or approximately 3 per cent of the urinary radioactivity. In the particular experiment described, epiœstriol (3, 16β, 17β) was estimated to account for approximately 6 per cent and œstriol (3, 16α, 17β) approximately 30 per cent of the total urinary radioactivity. Whether the 16-hydroxy ring *D* ketols are derived from the hydroxylation of œstrone or from oxidation of the corresponding triols will be the subject for future studies.

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Biological Deamidation of Nicotinamide in Vertebrates

An enzyme bringing about the deamidation of nicotinamide was demonstrated for the first time in lactic acid bacteria[1] and later in yeast[2] and *Mycobacteria*[3]. Studies in this laboratory have revealed the presence of nicotinamide-deamidating enzymes in *Neurospora crassa*[4] and the insect larva *Corcyra cephalonica* St.[5] and that the predominant feature of the vitamin metabolism in these organisms is the deamidation of nicotinamide. In the course of a study of the comparative metabolism of the vitamin in a variety of organisms, the liver and the kidney of several vertebrates have been examined for nicotinamide deamidase activity. A cell-free homogenate of the tissue was prepared in ice-cold distilled water and the enzyme activity measured as described earlier[4]. The results are presented in Table 1.

Table 1. Distribution of Nicotinamide Deamidase in Vertebrate Tissues

Nicotinamide deamidase activity is expressed as free nicotinic acid released (μgm.) in 60 min. at 37° C. in a 2-ml. system by cell-free homogenate equivalent to 100 mgm. of fresh tissue

Organism	Nicotinamide deamidase activity	
	Liver	Kidney
Rat	0·3	0·4
Rabbit	15·0	3·8
Guinea pig	5·0	1·6
Sheep	4·5	1·5
Hog	4·8	2·1
Cattle	2·7	1·5
Pigeon	252·0	760·0
Chick	0·7	>219·0*

* Complete deamidation of added nicotinamide in the incubation system.

It is seen that the tissues of the rat, guinea pig, sheep, hog and cattle are not able to deamidate nicotinamide *in vitro*. Rabbit liver exhibits a feeble deamidating activity, the kidney being inactive in this respect. It is interesting, on the other hand, that the tissues of the avian species, the pigeon and the chick, have very high nicotinamide deamidase activity. Surprisingly, however, while both the liver and the kidney of the pigeon are rich in the enzyme, only the kidney of the chick is able to deamidate nicotinamide.

The nicotinamide deamidase activity of *N. crassa*, *Mycobacteria* and *Corcyra* is localized in the soluble intracellular cytoplasmic matter, and can be recovered in the supernatant fraction obtained on high-speed centrifugation of their homogenates. In the case of the pigeon tissues, however, less than 10 per cent of the total activity could be obtained in the supernatant. The intracellular distribution of the nicotinamide-deamidating activity in the pigeon tissues was therefore investigated. Homogenates of pigeon liver and kidney were prepared in ice-cold isotonic sucrose and centrifuged differentially[6] to yield the sub-cellular components, which were then assayed for the enzyme activity. The purity of the individual fractions was not established in this study from the biochemical and cytogenetical viewpoint; nevertheless, it is evident (Table 2) that the particulate material in either tissue contains most of the enzyme.

These results constitute the first demonstration of nicotinamide deamidase in vertebrate tissues. The significance of this deamidation of nicotinamide as a major pathway in the vitamin metabolism in birds, micro-organisms and the insect *Corcyra cephalonica* is not entirely clear. However, these organisms exhibit a common characteristic in being apparently incapable of methylating nicotinamide[4,5,7,8], unlike many other vertebrates. The methylation and the deamidation of nicotinamide are thus probably alternative pathways in the metabolism of the vitamin. If this is so, the deamidation of nicotinamide, being a hydrolytic split, should be more economical from the point of view of bio-energetics than methylation, which requires the provision of energy[8].

Table 2. DISTRIBUTION OF NICOTINAMIDE DEAMIDASE IN THE SUBCELLULAR COMPONENTS OF THE LIVER AND THE KIDNEY OF THE PIGEON.

The incubation system (2 ml.), buffered at *p*H 7·5, contained nicotinamide (2·5 mgm.) and cell fraction equivalent to 50 mgm. of fresh tissue. Incubation at 37° C. for 120 min. in the case of liver and 90 min. in the case of kidney

Fraction	Liver			Kidney		
	Nicotinic acid released (μgm.)	Per cent total activity	Nicotinic acid released per mgm. nitrogen* (μgm.)	Nicotinic acid released (μgm.)	Per cent total activity	Nicotinic acid released per mgm. nitrogen* (μgm.)
Unfractionated homogenate	252·0	100·0	192·3	570·0	100·0	422·3
Nuclei	162·3	64·3	417·6	141·0	24·7	363·4
Mitochondria	83·0	32·9	389·6	334·0	58·6	1421·0
Microsomes	43·0	17·1	201·8	70·5	12·4	298·7
Supernatant	21·4	8·3	36·5	45·0	7·9	78·9

* Nitrogen present in enzyme preparation, and insoluble in trichloroacetic acid, determined by Nesslerization of a sulphuric acid–hydrogen peroxide digest.

The highly selective distribution of nicotinamide deamidase, evident from the fact that most of the vertebrates examined, the avian species excepted, do not possess the enzyme and that in the chick, whereas the liver is completely devoid of the enzyme, the kidney has it in abundance, would point to the specific nature of the enzyme as against its being a peptidase or similar enzyme acting non-specifically.

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Chromatographic Detection of Minute Quantities of Thyroxine in Serum

EFFORTS to detect extracted iodized compounds directly on chromatograms have been made by various authors while following the metabolism of thyroid hormones. Nevertheless, because of low sensitivity of the agents currently employed (ninhydrin, diazotized sulphanilic acid) this has proved fruitless. By modifying the original Sandell–Kolthoff reaction for iodine estimation, Bowden *et al.*[1] succeeded in detecting 0·1γ of thyroxine. The detection of thyroxine following chromatography of serum required the use of large amounts of the biological material[2]. Moreover, careful purification of the extract for chromatography was laborious and time-consuming. Efforts made so far[1,3] have likewise failed to bring about the desired results because the colour spots are of short duration.

By means of a minor modification of the procedure of Bowden *et al.* we have succeeded in detecting thyroxine in 1·0 ml. of serum. The chromatogram was sprayed with a solution (1 : 1) of ceric ammonium sulphate (0·2 N) – sodium arsenite (1·0 N) and left approximately 15 min. to dry at room temperature after a preliminary superficial desiccation. It was then passed through a 0·5 per cent solution of fluorescein in acetone, or a 5·0 per cent solution of anthranilic acid in acetone. When the chromatogram had dried in a free current of air, thyroxine was detected by means of ultra-violet light. For a visual localization of thyroxine the chromatogram was gently sprayed with a 1·0 per cent solution of *o*-toluidine in acetone instead of the fluorescein solution. Spots, pale yellow in colour, appeared on a background of dark brown. These spots remain stable for a considerable period of time and the colour contrast increases with time. The sensitivity attained by these processings is of the order of 0·01γ of thyroxine.

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Nature of the Carcinogenic Substance in Egg-Yolks

A HIGH incidence of malignant tumours was recently reported in mice fed egg-yolks[1], and the presence of a growth-promoting factor in the yolks has been thought to be responsible for this effect[2]. This substance was found to be soluble in common fat solvents and it is contained in the non-saponifiable and non-phospholipid portion of the yolk[3].

In the course of my investigations concerned with the isolation of the tumour-enhancing factor, I have prepared a lipoid substance accelerating the growth of experimental tumours in animals as well as stimulating the incorporation of labelled methionine-^{35}S into the proteins of Ehrlich ascites carcinoma *in vitro*. Only traces of this material are present in tissues of normal mice and rats when compared with organs of tumour-bearing animals.

The active substance is readily extracted from the unsaponifiable portion of fresh tissues or frozen-dried organs by benzene, acetone or ether. It is not adsorbed on alumina columns, but retained to some extent on anion-exchange resins, from which it can be displaced by means of weak acids. A paper chromatographic procedure has been applied for the isolation of the factor from eluants after ion-exchange chromatography.

The pure material is readily soluble in water and common fat solvents, giving an intensive yellowish fluorescence and characteristic ultra-violet absorption spectra. It is labile to heat (90° C.), destroyed by repeated freezing and thawing, but not by freeze-drying. No detailed chemical analyses could so far be carried out of a very small quantity of active material which could be recovered from tissues of tumour-bearing rats. The properties of this material so far examined suggest its close relation to aromatic hydrocarbons, possibly bile acids. It is definitely different from the phospholipid substance described by Green and Wilson[4].

When the properties of the growth-promoting substance from yolks were reported, it seemed to us worth while to examine the possible identity of this factor with the material derived from tissues of tumour-bearing animals. Application of the procedures used in the isolation of tumour-enhancing factor from animal tissues to the unsaponifiable portion of yolks gave a considerable quantity of a fluorescent substance the chromatographic behaviour and the absorption spectra of which were identical with those given by material from rat tissues. These facts strongly support our concept that the growth-promoting factor in egg-yolk and the tumour-enhancing factor are identical.

It is hoped to determine the chemical nature of this substance shortly, because considerably larger quantities of this material are available in egg-yolk than in rat tissues.

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Efficient Trace-labelling of Proteins with Iodine

IN the methods of iodination currently used only the cationic portion of the iodine molecule becomes bound to the ring structure of tyrosine, so that the theoretical efficiency of labelling is 50 per cent. In practice, efficiencies are always lower than this and may be only a few per cent when the ratio of iodine to protein used is less than one atom per molecule. Values greater than 50 per cent can be obtained by adding oxidizing agents to liberate iodine from iodide, but most if not all of these appear to affect adversely the properties of the labelled protein.

Iodine-131 monochloride was therefore prepared and used in dilute aqueous solutions for labelling proteins. Efficiencies were twice those obtained with labelled elementary iodine in similar circumstances. Essentially the same result was achieved by merely adding carrier-free radioactive iodine to inactive carrier iodine monochloride, provided the radioiodine used was free of reducing agent. (Iodine-131 condensed into *N*/50 sodium hydroxide can be obtained for this purpose from the Radiochemical Centre, Amersham, subject to an extra handling charge. Very little appears to be known about the ionic equilibria obtaining in this solution.) The radioiodine may be added to the carrier iodine monochloride, in dilute hydrochloric acid solution, before or after conversion of the iodine monochloride to hypoiodite. This step, which is indicated by the loss of the characteristic yellow colour of iodine monochloride, appears to be a prerequisite for substitution of iodine in the benzene ring of tyrosine. The conversion is best carried out by injecting a glycine buffer of *p*H 8·5 into the iodine-131 monochloride solution just prior to rapid mixing with the protein. The *p*H of the protein solution should not be higher than 9·5 since hypoiodite is unstable above this *p*H. Using this procedure 60–80 per cent of the radioactivity used was bound to proteins provided the molar ratio of iodine monochloride to protein was greater than 2. This applied to plasma albumins and globulins of various species, including some antibodies and pathological human globulins.

Lower efficiencies were obtained using lower molar ratios because of preferential utilization of the iodine monochloride for non-specific oxidations and especially of sulphydryl. The hydroxyl group of tyrosine is not ionized at *p*H 4·5 so that iodination does not occur, while oxidations proceed normally at this *p*H. Protein solutions which had been in contact with excess iodine at *p*H 4·5 and were afterwards passed through an ion exchange column to remove iodine and iodide then reacted with iodine-131 monochloride at *p*H 8–9 giving 90 per cent incorporation of the label at all molar ratios greater than 2, and 50–60 per cent incorporation at molar ratios as low as 0·1. Alternatively the approximate amount of iodine monochloride required for non-specific oxidation in each case was determined in a preliminary tracer experiment at *p*H 8–9 and this amount of inactive iodine monochloride added to a fresh portion of protein. The iodide formed was removed by ion exchange and the oxidized protein then iodinated with iodine-131 monochloride at full efficiency.

These increased efficiencies make labelling with iodine-131 a more economical procedure and one that is less hazardous to the operator since iodine monochloride has a much lower volatility than iodine. In addition, they offer the practical possibility of labelling only a small proportion of all protein molecules present. The biological behaviour of protein molecules labelled in severely competitive conditions in this way is now being studied.

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Separation and Determination of Millimicrogram Amounts of Cobalt and Microgram Amounts of Copper in Biological Material

THE chemical determination of metals chemically bound in biological material at concentrations less than 10^{-6} gm./100 gm. raises considerable difficulties. This is due to the fact that not all sensitive methods of determining metals in homogeneous material can be adapted to the treatment of samples containing organic compounds in the presence of an excess of other metals.

When undertaking the investigation of biological material, it is necessary first to separate the mineral components from the substrate by ashing the organic substances present therein, and then to select sufficiently sensitive methods for the determination of each of the various elements after they have been separated from one another. To exemplify the procedure followed, the determination of the cobalt and copper contained in whole blood has been chosen.

Available data point to a concentration of cobalt[1] of the order of 10^{-8} gm. and of copper[2] of 10^{-6} gm. in 100 gm. of whole blood. Since the amount of blood in clinical tests usually does not exceed 10 gm., the cobalt and copper contents in a sample would be of the order of 10^{-9} gm. and 10^{-7} gm. respectively.

We have separated both elements by paper chromatography from other metals (in the first place iron) of the blood, and applied emission spectrography for their quantitative determination. The detailed description of the determination of cobalt and copper is based on the method elaborated for determining cobalt in the blood, as given in an earlier paper[3].

The blood sample, after drying and ashing in an electric oven, is dissolved in acids. The solution of the metals present in whole blood is subjected to paper chromatographic analysis, using concentrated ammonium hydroxide as solvent, and Whatman No. 1 filter paper (14·5 cm. × 20·0 cm.). The solution is laid on along a line 3 cm. from the shorter edge of the sheet. The longer sides of the latter are then sewn together at two points to form a cylinder which is placed within the chromatographic chamber, the end nearer to the layer of the substance investigated being dipped in a solution of concentrated ammonia. In the chromatographic process the ferric ion remains at the starting line, since it is bound to the hydroxyl ion forming ferric hydroxide, which is insoluble in water. The ammonium compounds of the bivalent cobalt and copper ions, which are soluble in water, migrate along the filter paper together with the solvent front. The process is interrupted when the solvent has proceeded about 10–12 cm. above the starting line; the paper cylinder is dried at 80° C. in a position inverse to that in the chromatographic chamber.

Simultaneously, two tests are made with control solutions of salts of cobalt and copper, the presence of which is detected with a solution of α-nitroso-β-naphthol.

The paper strip containing the 'solvent front' is rolled up, placed upon silver foil and ashed carefully in the reducing flame of a Bunsen burner. The foil holding the ashed strip of filter paper containing the total amount of cobalt and copper present in the blood aliquot is now employed as an electrode, the other electrode being a silver rod; the distance between electrodes is 7 mm. The wave-lengths of the spectrum range from 2500 A. to 7000 A. Photographs are taken upon *G*22 photographic plates, with 150 diaphragm breadth and 10 sec. exposure. The plates are developed with a solution of hydroquinone in alcohol for 3 min. at 18° C. The interrupting bath in 5 per cent acetic acid lasted 15 sec. On applying an acid fixer, the plates were rinsed in running water for 30 min. at 18° C. and dried in air of the same temperature.

In order to obtain spectrographic standard curves, a series of measurements was made with known cobalt and copper solutions, containing 1·0–15·0 mμgm. cobalt and 5·0–30·0 μgm. copper simultaneously. The blackening of the 3453·5 A. line for cobalt and that of the 3247·5 A. line for copper was determined microphotometrically on the same plate. Results for cobalt and copper determinations in whole human blood are shown in Table 1, and they do not differ from those published by others using different methods.

Table 1. DETERMINATION OF COBALT AND COPPER IN HUMAN BLOOD

No. of blood sample	Cobalt (mμgm.) per 100 gm. of blood	Average	Copper (μgm.) per 100 gm. of blood	Average
1	34·3	34·7	22·0	22·2
	37·0		23·0	
	33·3		22·0	
	34·3		21·8	
2	41·1	41·5	19·7	19·3
	43·3		18·6	
	41·0		20·0	
	40·6		18·8	
3	41·0	42·7	19·9	19·2
	44·0		19·0	
	42·6		19·7	
	43·3		18·3	
4	50·4	49·9	9·7	9·5
	49·0		9·1	
	51·3		10·0	
	49·0		9·3	

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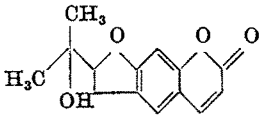
Isolation of Marmesin from the Fruits of *Ammi majus* Linn.

Ammi majus Linn. (Umbelliferae) is a wild plant which grows in Egypt, producing fruits reputed for their use in the treatment of leucodermia. They are mentioned in old Arab literature[1], and their value has recently been established by clinical investigations[2]. In 1947, Fahmy and Schönberg and their associates[3] reported the isolation of three crystalline compounds—ammoidin, ammidin and majudin—from the petroleum ether extract of the fruits. These compounds, or in any event the first two, were shown to be efficacious in the treatment of leucodermia[4–6], and are produced commercially (by The Memphis Chemical Co., Zeitoun, Cairo) for that purpose. Shortly afterwards, Schönberg[5,7] demonstrated that ammoidin and ammidin are actually the furocoumarins xanthotoxin[8] and imperatorin[9] respectively, and majudin was shown to be bergapten[4].

We wish now to report the isolation of another crystalline compound from the fruits of *A. majus*. After exhaustive extraction with benzene to remove fat and the furocoumarins mentioned above, the powdered seeds were extracted with hot ethanol and the extract, concentrated to a small bulk and hydrolysed by refluxing with mineral acid. After processing in the usual manner and repeated crystallization of the product from ethanol, a colourless crystalline compound, $C_{14}H_{14}O_4$, molecular weight 249–253 (Rast), melting point 189–190° C., was obtained in 0·25 per cent yield. The compound, optically active, $[\alpha]_D + 25°$, sublimes unchanged at 140–150° C., 1 mm. mercury and gives a yellowish colour with concentrated sulphuric acid. The compound itself and its solution in alcohol or concentrated sulphuric acid fluoresce strongly in the blue-violet under ultra-violet light. As the compound was suspected of being another furocoumarin of *A. majus* existing naturally as a glycoside, experiments were carried out to test this possibility. (From the related *Ammi visnaga*, the furochromones khellin, visnagin and khellol glucoside were isolated; for references, see ref. 10.) The aglycone was found to be insoluble in cold aqueous alkali, but readily soluble in alcoholic alkali, giving a stable yellow solution from which the original substance is precipitated on acidification. Upon fusion with potassium hydroxide, resorcinol was obtained. The compound contained no methoxyl or aldehydic groups and gave no ferric chloride reaction. The hydroxylic content of the compound, however, was apparently tertiary, since it did not react with diazomethane or with acetic anhydride – pyridine mixture at room temperature or upon warming. Nevertheless, a mono-acetate, $C_{16}H_{16}O_5$, melting point 130–2° C., $[\alpha]_D + 25$ deg., was obtained by refluxing in acetic anhydride solution containing anhydrous sodium acetate. Refluxing with benzoyl chloride gave, instead of a benzoate, an optically inactive compound, melting point 134–135° C., identical with an anhydro-derivative obtained by treatment with phosphorus pentoxide. This was taken as an evidence suggesting that the hydroxyl group is close to the asymmetric centre.

Since all the evidence pointed to the possibility that the aglycone might be marmesin (I) (melting point 189·5–190° C., $[\alpha]_D + 26 \cdot 8$ deg.)—a dihydrofurocoumarin occurring freely in the bark of *Aegle marmelos*, Corrêa (Rutaceae), and first isolated by Chatterjee and Mitra[11]—other derivatives were prepared and were found to support the suggestion.



(I)

Final proof of the identity of the aglycone was sought by carrying out a determination of the mixed melting point with an authentic sample of marmesin (no depression was found) and by comparing the spectra (which were identical). Marmesin is the optical antipode of nodakenetin which occurs as a glucoside in *Peucedanum decursivum*[12]. Further experiments on the product are in progress and a study of its physiological properties is being carried out and will be reported, together with the details of this work, elsewhere.

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Lutein in a Bacterial Membrane

CAROTENOIDS have been noted as constituents of a number of bacteria[1], possibly associated with protein compounds[2]. In a chemical analysis of the protoplast membrane of *Micrococcus lysodeikticus*[3], the absorption spectrum of a solution of the lipid fraction in petroleum ether, obtained by solvent extraction of the membrane, indicated the presence of lutein. However, the carotenoid was unstable in organic solvents and consequently the quantitative estimation gave a value believed to be low. It has now been found possible to determine the pigment in the membrane without preliminary extraction.

Micrococcus lysodeikticus was grown under the conditions given previously[4]. Protoplast membranes were isolated by differential centrifugation of lysozyme-induced lysates by a method previously described in detail[3]. The absorption spectrum between 300 and 800 mμ of a fresh suspension of membranes in 0·05 *M* sodium chloride solution was measured, using a 'Unicam *SP* 500' quartz spectrophotometer. As shown in Fig. 1*B*, the absorption spectrum of lutein is sharply evident, superimposed on the curve produced by the scattering of light by the suspended membranes. For comparison, the absorption spectrum of the membrane lipid dissolved in petroleum ether is given in Fig. 1*A*. With intact protoplasts, the non-specific scattering masks absorption by pigments.

In order to calculate the specific absorption in the membranes, the optical density – wave-length curve in the absence of specific absorption was calculated by a method based on Heller and Vassy[5]. A log–log plot of optical density against wave-length between 500 mμ and 800 mμ yielded a straight line of slope −2. This line was extrapolated to shorter wave-lengths

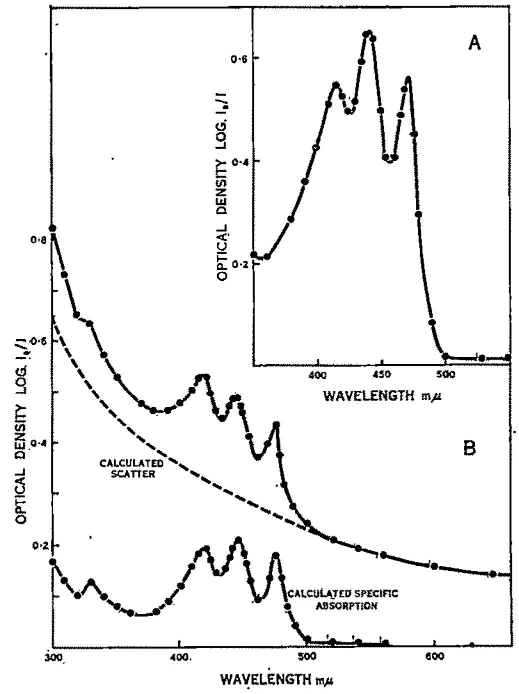

Fig. 1. Absorption spectra of *M. lysodeikticus* protoplast membrane lipid and protoplast membrane suspensions: *A*, Protoplast membrane lipid 1·1 mgm./ml. in petroleum ether; *B*, protoplast membrane suspension 0·68 mgm. dry weight/ml. in 0·05 *M* sodium chloride solution

and used to derive the calculated curve due to scatter in Fig. 1*B*. Thence, by difference, the specific absorption in the membrane was obtained.

The positions of the specific absorption peaks of the membranes are almost identical with those of lutein dissolved in hexane[6] and of the membrane lipid in petroleum ether[3]. The absorption spectrum of the membranes indicates a lutein content in the dry membrane of 0·14 per cent w/w. This is twice the value estimated on the extracted lipid[3]. Even the present estimate is probably too low, since Duysens[7] has shown that the absorption spectrum of absorbing particles, even if properly corrected for scattering, must appear flattened compared with that of the same number of molecules in a homogeneous solution.

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Effect of Bile Salts upon the Activity of Antibiotics

IN the course of studies on the effect of bile salts upon the activity of a variety of antibiotics it was observed that the susceptibility to neomycin of a series of recently isolated strains of staphylococci (which are pigmented, coagulase positive, hæmolytic, and ferment mannitol) and of enterococci was increased when the *in vitro* tests were performed in a medium to which 0·5 per cent bile salts (Difco) had been added, as shown by the significant and consistent reduction in the minimum amount of antibiotic required to inhibit the growth of standard inocula of these strains in bile-salts medium as compared with the same medium without adjuvant (Table 1). The same concentration of bile salts also resulted in enhanced activity of penicillin against staphylococci resistant to penicillin, but had little or no effect upon the efficacy of this antibiotic against penicillin-sensitive strains of the same species or strains of enterococci tested. No such consistent potentiation against either resistant or sensitive strains was observed with bacitracin, chloramphenicol, erythromycin, nitrofurantoin, novobiocin, oleandomycin, streptomycin and tetracycline. With polymyxin, ristocetin and vancomycin, however, an opposite effect to that noted above was observed, namely interference, since significantly greater amounts of each of these antibiotics were required to inhibit similar inocula of a number of strains of both Gram-positive species in bile salts medium than was required in plain medium.

Table 1. POTENTIATION OF ANTIBACTERIAL ACTIVITY OF NEOMYCIN AND PENICILLIN AGAINST STAPHYLOCOCCI AND ENTEROCOCCI BY 0·5 PER CENT BILE SALTS

Strain	Minimum inhibitory concentration of: Neomycin (μgm./ml.)		Penicillin (units/ml.)	
	Assay broth	Assay broth + 0·5 per cent bile salts	Assay broth	Assay broth + 0·5 per cent bile salts
Staphylococcus aureus				
0448	1·0	0·1	9·0	0·8
0598	0·3	0·04	4·0	1·0
0620	0·2	0·1	10·0	4·0
0196	0·4	0·03	8·0	2·0
0267	0·5	0·05	10·0	1·0
0756	0·5	0·04	0·6	0·4
1008	0·1	0·03	1·0	0·7
1020	1·0	0·1	0·4	0·4
0785	0·5	0·05	0·2	0·3
1167	0·2	0·05	0·2	0·2
Streptococcus faecalis				
0095	7·5	1·0	10·0	10·0
0145	4·0	0·5	10·0	10·0
0310	5·0	2·0	10·0	8·0
0372	4·0	0·5	10·0	10·0
0457	5·0	2·0	10·0	10·0
0485	8·0	2·0		
0491	10·0	1·0		
0608	3·0	0·5		
0668	7·5	2·0		
0779	4·0	0·4		

As regards such Gram-negative bacteria as *Escherichia coli*, *Aerobacter aerogenes*, *B. proteus* and *B. pyocyaneus*, with the exception of polymyxin, bile salts had neither an enhancing nor an antagonistic influence upon the antibiotics ordinarily employed against them, namely, chloramphenicol, neomycin, nitrofurantoin, streptomycin and tetracycline. Bile salts did interfere markedly with the action of polymyxin against these micro-organisms since considerably greater concentrations of polymyxin were required to inhibit their growth in the presence of bile salts. Thus, depending upon the antibiotic and the bacterial species against which it is employed, bile salts produce a diversity of effects, in some instances enhancement of antibacterial activity, in others interference, while in still others no effect whatever.

The medium employed in these studies consisted of 'Trypticase' 7·5 gm., 'Phytone' 1·3 gm., sodium chloride 2·15 gm. and potassium phosphate 1·05 gm. per litre of distilled water adjusted to *p*H 7·2, to which sterile 0·5 per cent bile salts (Difco) was added where indicated. Tests were performed by the tube-dilution method in 2-ml. amounts by adding 1 ml. of a 10^{-4} dilution of a culture of the strain under test (which had been maintained at 37° C. for 6 hr.), adjusted to an optical density of 0·05 on a 'Lumetron' colorimeter (650 mμ), to a series of tubes containing varying concentrations of standard antibiotic in 1 ml. of appropriate medium. Readings were taken after incubation for 24 and 48 hr. at 37° C., but since no marked changes in the observed differences between both media occurred between 24 and 48 hr., only the findings noted after incubation for 48 hr. are recorded in Table 1.

Further experiments in an attempt to elucidate the mode of action of bile salts and to determine whether an element or elements contained in the mixture might be responsible are in progress. The addition of 0·5 per cent bile salts has been found to have neither a significant stimulatory nor inhibitory effect upon the rate or intensity of growth of the bacterial species investigated and does not change the *p*H of the medium.

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Influence of Temperature and Light on Thyroid Function

Forty-four mature male albino rats weighing 150–180 gm. were divided into four equal groups. Two of these groups were kept at a temperature of 18° C., while the other two groups were maintained at 35° C. One group maintained at each temperature was kept continuously in light of intensity 30 ft.-candles, and the other groups were kept in darkness. After 12 days the animals were killed by decapitation under light ether anæsthesia, and their blood was collected. The levels of thyroid and thyrotrophic hormone in their serum was determined by the use of the stasis tadpole method[1]. The tadpoles were divided into five groups, each of twenty animals. A control group was injected with saline. The other groups of tadpoles were injected on alternate days with five injections of 0·02 ml. of serum obtained from the four groups of rats. Increase in length of the hindlimbs of the tadpole was the criterion of thyroid hormone concentration, while the increase in thyroid epithelial cell height was used as an index of thyrotrophic hormone-level in the serum of rats. The thyroids of the rats were examined histologically. They were fixed in Zenker without acetic acid and stained with Mallory's stain[2]. Analyses of variance and of correlation were performed.

At 18° C. the thyroids of the rats kept in darkness were heavier than those of rats exposed to light. At 35° C. the thyroids of the rats exposed to light were heavier than those of rats kept in darkness. The rats kept at 18° C. had more active thyroids and higher epithelia than those kept at 35° C. These findings are in agreement with those obtained by other investigators, indicating increased activity of the thyroid under the influence of cold and decreased activity at higher temperatures[3].

The rate of metamorphosis and the epithelial cell heights of tadpoles injected with serum obtained from rats confined to darkness at 18° C. were greater than those of rats maintained at the same temperature and exposed to light. At 35° C. this effect was reversed. Exposure to light induced a significant increase in thyroid and thyrotrophic hormones in the blood, whereas darkness decreased their level. These results indicate that there is a significant interaction between the effects of temperature and light on thyroid weights and levels of thyroid and thyrotrophic hormones.

Table 1. Influence of Temperature and Light on Thyroid Function

Treatment	Data obtained from rats		Data obtained from tadpoles	
	Thyroid wt. mgm./100 gm. body weight	Epithelial cell height (μ)	Mean increase of hind limbs above control (mm.)	Mean increase of epithelial cell height above control (μ)
Cold–light	5·77 ± 0·68	10·47 ± 0·04	1·01 ± 0·53	2·49 ± 0·01
Cold–dark	7·97 ± 0·44	11·63 ± 0·01	5·04 ± 0·97	4·62 ± 0·14
Temperature–light	7·45 ± 0·55	9·36 ± 0·14	5·01 ± 1·08	4·12 ± 0·17
Temperature–dark	5·38 ± 0·67	9·53 ± 0·01	1·81 ± 0·57	2·24 ± 0·20

± Standard error.

Although the levels of thyroid and thyroid stimulating hormones were high in the blood of rats kept at 35° C. and exposed to light, yet their thyroids were inactive from the histological point of view. The thyroid-stimulating hormone produced under such conditions is probably a stimulant to thyroid secretion, rather than to cell height.

Some investigators have found that exposure of animals to light stimulated thyroid function, while others state that rats confined to darkness have more active thyroids[4]. In the light of our results, it appears that the environmental temperature can modify or even reverse the effects of light and darkness on thyroid function.

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Influence of the Thymus on the Reaction of the Adrenal to Adrenocorticotropic Hormone in the Rat

It has been shown previously that thymectomy is followed by a transitory stimulation of the adrenal in guinea pigs[1]. I have investigated whether this is due to interference of the thymus with the action of adrenocorticotropic hormone.

Eighty-eight male rats of a local inbred strain weighing 130–160 gm. were divided into two groups. Twenty-four rats in the first group were hypophysectomized, using Smith's method. Forty-eight rats in the second group were thymectomized by Segaloff's method and hypophysectomized ten days later. The technique of both operations was that described by Farris and Griffith[2]. From the sixth to the tenth day after the hypophysectomy, twenty-four thymectomized, hypophysectomized animals were injected daily with the thymus extract of Bezssonoff and Comsa[3], at the daily dose of 15, 30, 40, 50, 70 and 100 units[4] (four animals for every dose).

The hypophysectomized animals were kept at a constant temperature of 29 ± 5° C.

On the eleventh day after hypophysectomy, the animals were given a single intraperitoneal injection of adrenocorticotropic hormone (supplied by Messrs. Choay, Paris) as follows: (1) The hypophysectomized and the thymectomized and hypophysectomized animals which had not been treated with thymus extract received 0·4, 0·7, 1·0, 1·5 and 2·0 units (four animals of each group for every dose). (2) The thymectomized and hypophysectomized animals which had received injections of thymus extract were each given 0·4 units of adrenocorticotropic hormone.

The animals were killed with chloroform two hours later, and the vitamin C content of the adrenals was determined individually by the method of Roe and Kuether.

Control determinations were performed on 8 normal male rats of the same strain, age and diet; on 4 thymectomized animals; on 4 hypophysectomized animals; on 4 thymectomized and hypophysectomized animals; and on 4 thymectomized animals injected daily for four days with 100 units of thymus extract.

In the control groups, the following vitamin C content of the adrenal was found (μgm. per mgm. of fresh tissue):

Normal males	3·16 ± 0·11
Thymectomized	1·76 ± 0·20
Hypophysectomized	7·08 ± 0·18
Hypophysectomized and thymectomized	4·20 ± 0·20
Hypophysectomized, thymectomized and injected with thymus extract	4·37 ± 0·18

Thus thymectomy was followed by a significant decrease in the vitamin C content of the adrenals. Hypophysectomy resulted in an increase of the vitamin C content in both normal and thymectomized animals. In these, thymus injections by themselves showed no additional influence on the vitamin C content.

The results with animals which received injections of adrenocorticotropic hormone are recorded in Tables 1 and 2. It can be seen that in thymectomized and hypophysectomized animals, the decrease of the vitamin C content of the adrenals (corresponding to the same doses of adrenocorticotropic hormone) is significantly greater than in simply hypophysectomized animals. The test dose of 0·4 units of adrenocorticotropic hormone produced in the first group a decrease of about one half of this content, whereas it had no detectable influence in the second. This consequence of thymectomy could be suppressed by injecting the thymectomized and hypophysectomized animals with thymus extract.

Thus the thymus is antagonistic to the action of adrenocorticotropic hormone, and its effect is supported by the thymus extract obtained by the method of Bezssonoff and Comsa.

Table 1. VITAMIN C CONTENT OF THE ADRENAL IN RATS 2 HR. AFTER A SINGLE INTRAPERITONEAL INJECTION OF ADRENOCORTICOTROPIC HORMONE

Adrenocorticotropic hormone dose (units)	Vitamin C (μgm./mgm. fresh weight): Hypophysectomized rats	Thymectomized and hypophysectomized rats
0	6·98 ± 0·13	4·20 ± 0·20
0·4	6·90 ± 0·20	1·85 ± 0·14
0·7	5·24 ± 0·10	1·74 ± 0·17
1·0	2·34 ± 0·18	1·44 ± 0·07
1·5	1·94 ± 0·13	1·40 ± 0·08
2·0	1·75 ± 0·05	1·38 ± 0·03

Table 2. VITAMIN C CONTENT OF THE ADRENAL IN RATS INJECTED WITH THYMUS EXTRACT AND 0·4 UNITS OF ADRENOCORTICOTROPIC HORMONE

Thymus dose (units)	Vitamin C content (μgm./mgm. fresh weight)
0	1·85 ± 0·14
15	2·02 ± 0·27
30	2·30 ± 0·09
40	2·95 ± 0·08
50	3·35 ± 0·15
70	3·71 ± 0·11
100	3·98 ± 0·17

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Effect of the Synthetic Œstrogen Stilbœstrol on Pregnancy in the Rabbit

IN a communication under the above title[1], Sharaf and Hafez state that they employed very large doses of stilbœstrol (single dose, 1 mgm. in the rabbit). It is doubtful whether a dose of such magnitude could be considered to have a specific effect peculiar to œstrogens since only a few micrograms are required to produce characteristic responses. No histological work was apparently carried out to determine whether the ovum was ever fertilized and, if so, how or why the blastocyst perished. I have been working on the reproductive hormones for some time and wish to direct attention to the fact that a good deal of work has already been done in this particular field and to the results so far obtained.

Csapo[2] has demonstrated the delicate hormone balance necessary in the rabbit for the successful implantation of the blastocyst. He found that a few micrograms of œstradiol prevent implantation, an effect which was not due to 'tubal block' or to failure of the histological process of progestational proliferation. He suggested that there might be a direct effect on the blastocyst itself.

Several workers have reported on the effects of administering œstrogen during the later stages of pregnancy in mice, rabbits, rats and guinea pigs and these papers are reviewed by Reynolds[3]. The results are not altogether in agreement, since some experimenters found that injected œstrogens interrupted pregnancy, whereas others found that pregnancy continued apparently normally, despite administration of œstrogen. In the rabbit, however, it has been shown[4] that the course of normal pregnancy is determined by the level of the ovarian hormones—pregnancy being maintained by the progesterone 'block'[5] which renders the myometrium unreactive. Consequently a dose of œstrogen may be large enough to break through this progesterone block and so interrupt pregnancy, whereas any dose smaller than this 'threshold' dose would be without effect on the course of pregnancy.

The œstrogen-level obtaining in the rabbit rises steadily from the middle of pregnancy[4]. If one assumes that pregnancy is disturbed only when the œstrogen-level is raised by a certain percentage, then the threshold dose of œstrogen required to break through the progesterone block would be increased as pregnancy proceeds. This would explain the finding of several workers[3] that as pregnancy advances more injected œstrogen is required to disturb it.

These considerations suggest that the divergence of the experimental results so far reported is due to quantitative differences and to an imbalance in œstrogen dosage. A dose of œstrogen sufficient to break through the progesterone block on the fifteenth day will probably be ineffective a few days later, when a higher dose is required to produce the same proportional disturbance in œstrogen-level. It would be necessary, therefore, to trace the effective dose throughout pregnancy in order to determine whether or not œstrogens, in doses small enough to have a specific action, are capable of interrupting pregnancy.

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Surface Tension of the Blood and Atherogenesis

'Triton *WR* 1339' is known to cause a marked rise of the lipæmia and cholesterolæmia when injected into experimental animals[1]. It has been suggested that the mechanism responsible for the enhancement of the cholesterol-level of the blood is an increased synthesis of cholesterol, chiefly in the liver[2], combined with an alteration in the exchange of cholesterol between the blood and the different organs. This results in a high cholesterolæmia, with normal or even lowered cholesterol-levels in the organs[3].

In order to investigate possible mechanisms to explain the rise in lipæmia, we have measured the alterations of surface tension of the blood in rabbits injected with 'Triton'. The surface tension of 5 ml. of citrated blood was measured by the platinum ring method with a du Noüy apparatus. In normal rabbits, the surface tension was found to have a constant value, the average surface tension in 140 rabbits being 57·4 dyne/cm. (standard deviation ±0·83; standard deviation of the mean ±0·07).

After a single injection of 400 mgm. 'Triton' per kgm. body-weight, an immediate fall of surface tension is observed; it is lowest 5 min. after the injection, and reverts gradually to normal values 14–21 days later. Cholesterol-levels reach a maximum after three days and become normal at about the same time as surface tension (Table 1). Smaller doses of 'Triton' have a similar but less pronounced effect on both surface tension and cholesterolæmia.

While the immediate change in surface tension can easily be explained by the influence of 'Triton' itself, the large amount of cholesterol and lipids present in the blood three days after the injection had to be examined as a possible cause of lowered surface tension. For this purpose, rabbits were given a diet consisting of pellets to which 1 per cent cholesterol and 3 per cent peanut-oil was added. Blood samples taken after 4 weeks showed a cholesterolæmia of 257·2 mgm. per cent and a surface tension of 53·9 dynes/cm. After 12 weeks the cholesterolæmia rose to 1,247 mgm. per cent, and surface tension was reduced to 51·0 dynes/cm.

Table 1. AVERAGE VALUES OF SURFACE TENSION OF BLOOD AND CHOLESTEROLÆMIA OF SIX RABBITS BEFORE AND AFTER INJECTION OF 400 MGM. 'TRITON' PER KGM. BODY-WEIGHT

	Surface tension (dyne/cm.)	Cholestorolæmia (mgm. per cent)
Before	57·0	46·5
After 5 min.	45·9	68·0
,, 3 days	47·0	349·8
,, 7 ,,	48·9	277·3
,, 14 ,,	52·2	162·5
,, 21 ,,	57·3	52·8

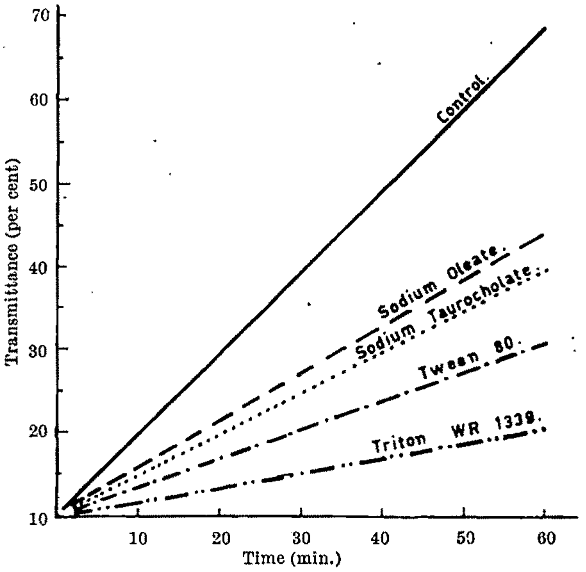

Fig. 1. Influence of surface-active agents on the heparin-clearing process *in vitro*. 1·2 ml. plasma of a rabbit injected intravenously with heparin is added to a mixture of 0·3 ml. of 1 per cent 'Ediol' and 1·5 ml. of 3 per cent albumin. Optical transmittance is measured immediately after mixing the ingredients and every 10 min. thereafter. 0·2 ml. of a solution containing 1·5 mgm./ml. of each surface-active agent to be tested was added, this bringing the final concentration to 0·1 mgm./ml. As a control the same volume of saline is used

After 12 weeks these rabbits were killed and anatomopathological examination of their aortas showed severe lipid deposits in the intima.

Another series of experiments demonstrated the inhibitory effect of various surface-active agents on the heparin-clearing mechanism *in vitro* (Fig. 1). In this blocking of the heparin-clearing mechanism, the enhanced lipæmia following injection of 'Triton' could find its explanation.

It is also of interest to note that plasma of rabbits injected with heparin failed to clear the highly lipæmic sera of rabbits injected with 'Triton', and of those that were fed the 1 per cent cholesterol diet for 12 weeks.

Other workers have found lowered surface tensions in known atherosclerotics and in a number of normal young adults[4]. In our laboratory a preliminary experiment on 10 young adults showed a definite lowering of surface tension of the blood 3 hr. after a meal chiefly consisting of saturated fats.

At this stage of investigation the exact significance of the surface tension of blood cannot be assessed. But the striking correlation between cholesterol and 'Triton' as surface-active agents and clearing inhibitors on one hand, and as atherogenous substances on the other, merits further investigation of the possible relation between lowered surface tension of the blood due to any cause, and atherogenesis.

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Water Activity of Mammalian Tissues

SINCE the original report by Sabbatani[1] that the freezing-point depression of various dog tissues is on the average 150 per cent greater than that of blood, there has been continued interest in the possibility that intracellular fluid is hypertonic to extracellular fluid. Collip[2], Leövey and Kerpel-Fronius[3], Gömöri and Molnár[4], and Pichotka *et al.*[5] all confirmed Sabbatani's findings, as did Opie[6] using melting-point depression.

However, these cryoscopic measurements have been criticized because any autolysis occurring during the interval between removal of the tissue from the animal and the end-point of the measurement will increase the number of solute molecules present and hence yield spuriously high values for the tonicity of the tissue. That a rapid increase in depression of the freezing point of tissues will occur even at 0° C. has been demonstrated by Conway and McCormack[7], and Conway *et al.*[8], and by Brodsky *et al.*[9]. Conway and McCormack[7] found that the freezing point of guinea pig kidney and liver suspended in isotonic saline was the same as that of serum. Furthermore, by taking into account the expected rate of autolysis, they claimed that the corrected freezing-point depression of other tissues of rat and guinea pig was also the same as that of serum. Brodsky *et al.*[9] were not able to confirm these extrapolated values (although Buckley, Conway and Ryan[10], on recalculating Brodsky's results, claim that the latter agree with those of Conway and McCormack[7]). By heating tissues in water at 98° C. for 30 min. immediately upon removal to reduce autolysis, Appelboom[11] recently has reported isotonicity with extracellular fluids.

Because of the conflicting results which have been reported and because recent workers, in attempting to circumvent autolysis, have utilized complex methods which may introduce unknown variables into the measurement, the following method employing the melting point was devised. Tissues were removed from anæsthetized animals and dropped immediately into liquid nitrogen. While still at the temperature of liquid nitrogen, the tissue was pulverized by mortar and pestle and the powder suspended in liquid silicone, a biologically inert fluid. For each measurement, a portion of tissue calculated to contain a specified amount of water was used. The plastic tube containing the mixture was placed in an evacuated, silvered jar. The mixture was then stirred rapidly and thus warmed at a constant rate by a stirring device of low thermal conductivity. The increase in temperature of the suspension was measured with a thermistor and recorded by a continuously balancing electronic potentiometer.

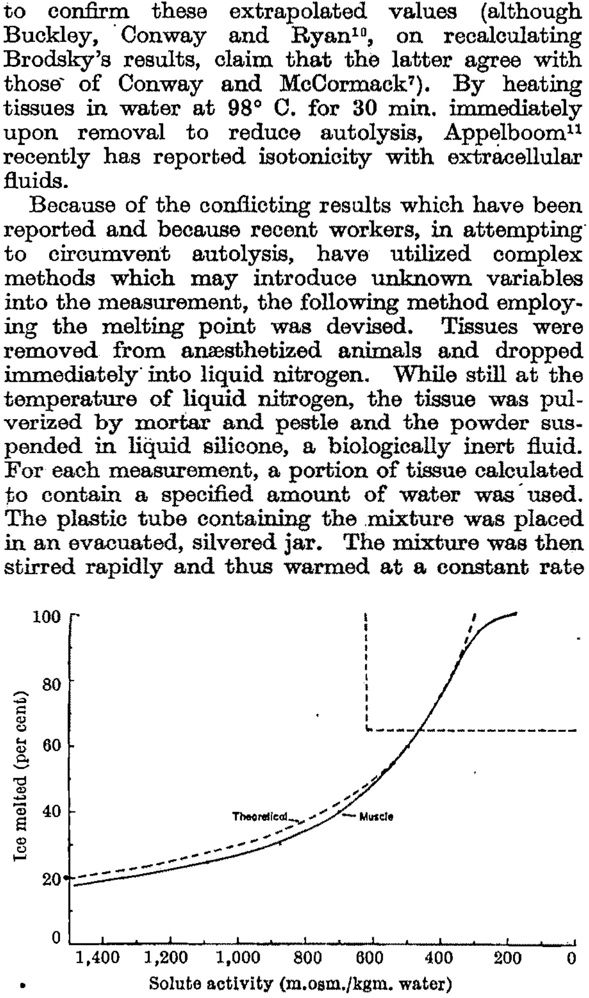


Fig. 1. Shape of the actual melting curve of rat muscle superimposed on a theoretical melting curve, a rectangular hyperbola

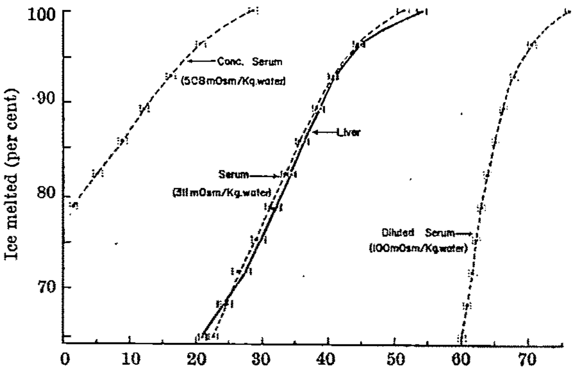
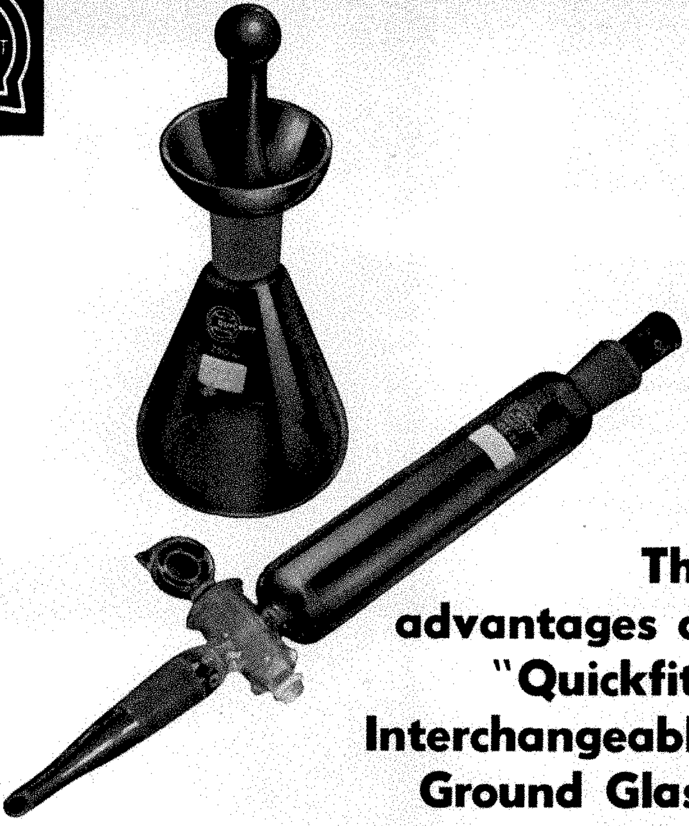


Fig. 2. Melting curves of rat liver, rat serum, concentrated rat serum and diluted rat serum

Since pure water separates as ice from a solution as it freezes, one may calculate the expected melting curve of the solution. For a given solution, when the percentage of ice melted is plotted against increasing temperature, or decreasing thermodynamic activity of solute or increasing thermodynamic activity of water, a rectangular hyperbola is obtained. Such a curve is shown as the broken line in Fig. 1. Corrections for the small changes in activity coefficients which would occur over the range of concentration shown would not appreciably alter the shape of the curve and have been neglected in the present treatment. For solutions of different activities a family of rectangular hyperbolas should result.

Fig. 1 also shows an actual melting curve of rat muscle—the solid line—superimposed on the rectangular hyperbola of the theoretical curve—the broken line. The fit is close, especially in the upper portion of the curve, and it is this portion, enclosed by the broken lines, which was used as an index of depression of melting point to avoid the uncertainty of extrapolating to the point of complete melting. Over this restricted range of concentration the effect of changes in activity coefficient will be minimized.

Fig. 2 shows the mean curve obtained from twelve separate measurements of the melting curve of rat liver and a similar number of measurements of rat serum. The ordinate represents the percentage of ice melted, and the abscissa the arbitrary potentiometer scale which is proportional to temperature or activity. The mean concentration of the rat serum was found to be 311 m.osm./kgm. water by an accurate freezing-point method. To indicate the concentration scale, the melting curves of serum concentrated by drying to 508 m.osm./kgm. water and diluted with distilled water to 100 m.osm./kgm. water have been included. The small vertical bars or rows of dots indicate the standard error of the mean for each point. It is evident that the melting curve of rat liver does not differ significantly from that of rat serum. Results with skeletal muscle, heart and brain also agreed with the value for serum. The melting curve of whole rat kidney was displaced approximately 10 per cent above that of serum, a difference attributed to the production of hypertonic urine in the medullary portion of this organ. When frozen tissue was exposed to room temperature for periods of 10 and 20 min., the subsequent measurement showed a



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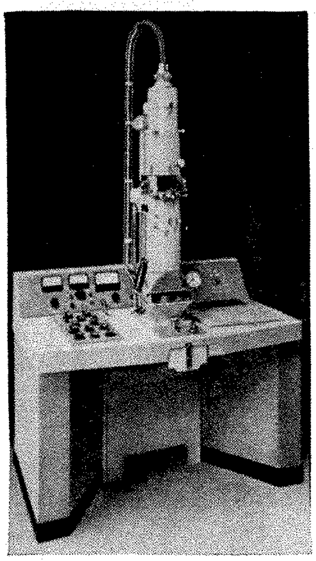

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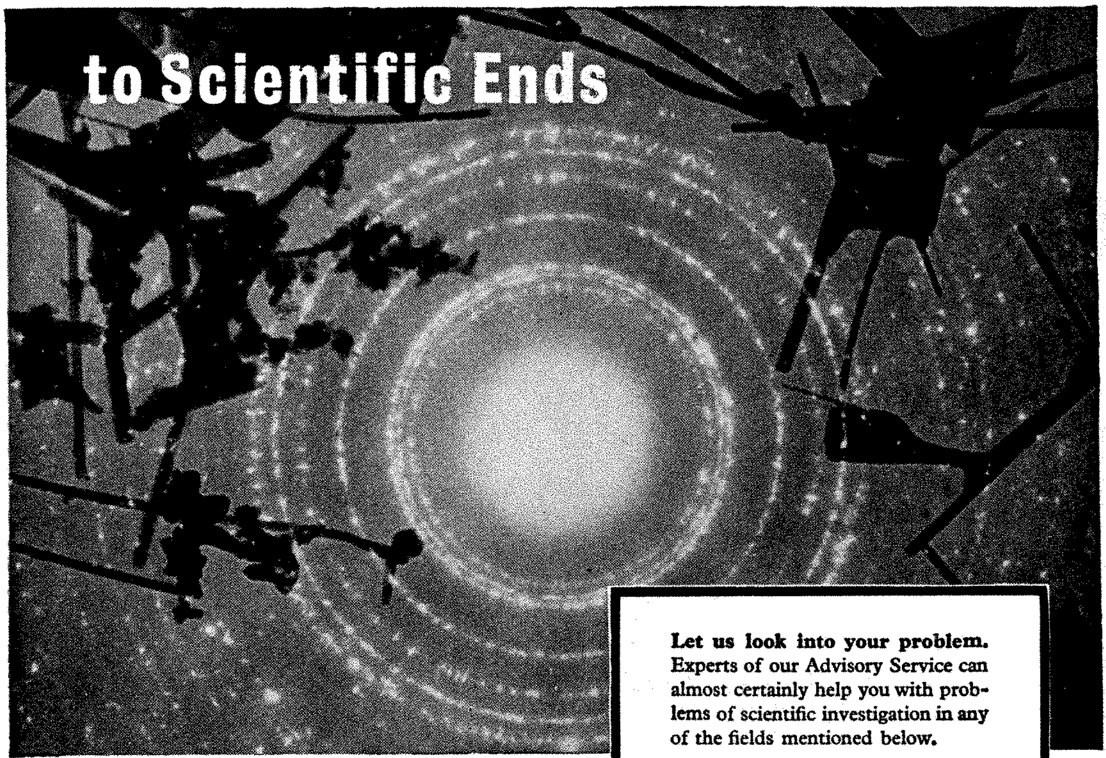

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marked increase in depression of the melting curve. This confirms that rapid autolysis will lead to spurious results.

These direct measurements demonstrate that the water activity within mammalian cells is the same as that of the extracellular fluids.

This work was supported in part by grants from the American Heart Association, the John A. Hartford Foundation, Inc. and the U.S. Public Health Service (grant *H*–2822).

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Part played by Deoxyribonucleic Acid in Transplantation Immunity

THE tissue incompatibility revealed by homografting is due to individual antigenic differences that cause the recipient to produce an immunity response to tissues grafted from another individual. Billingham, Brent and Medawar[1] used a transplantation immunity test in inbred strains of mice when studying the antigens responsible for the homograft reaction, and formulated the hypothesis that nuclear nucleoproteins or lipoproteins associated with them were responsible for transplantation immunity. The activity of nuclear fragments was not destroyed by the action of ribonuclease or trypsin but was destroyed by the action of deoxyribonuclease. We therefore decided to test whether tissue deoxyribonucleic acid itself acts as an antigenic stimulus in homotransplantation.

The transplantation immunity test devised by the above-mentioned authors was used, together with their method of evaluation. It is known that antigens responsible for transplantation immunity are present in different tissues of the same individual. We therefore prepared deoxyribonucleic acid from the liver, spleen and thymus of mice of the inbred strain *A* or *C*57 Black (males) using the method of Zamenhof *et al.*[2]. The harmlessness of this method of isolation was tested by demonstrating that it did not inactivate the pneumococcal transformation factor added at the beginning of the preparation[2]. It was therefore believed that this method should also preserve other biological characteristics of the deoxyribonucleic acid molecule. In addition, various procedures known to destroy transplantation antigens (tissue freezing, lyophilization, heating) were avoided. Deoxyribonucleic acid was dissolved and injected into mice of another strain (*CBA*) via the intraperitoneal route immediately following isolation, the preparation taking three days when a three-stage purification was used, and eight days with an eight-stage purification. The majority of these preparations contained traces of bound proteins (Table 1). Test transplantations of fresh donor skin were carried out on the fourth to fifth day after injection. Grafts were removed at the end of the sixth day after transplantation, prepared for histological examination and compared with negative and positive controls. Skin grafts on normal uninjected individuals served as negative controls and skin grafts on individuals previously immunized with tissue grafts from the same donor were positive controls.

The results show that deoxyribonucleic acid does not produce transplantation immunity comparable with immunity caused by a previous injection of donor tissue into individuals of the other strain. Only in a few cases was it possible to observe vacuolization of cells, pycnosis of nuclei of epithelial cells and an evident cellular host reaction (± in Table 1). In these respects the test grafts differed from the negative controls. The reaction after injection in these few cases did not seem to depend on either the dose of deoxyribonucleic acid or the quality of the preparation. Complete destruction of the test graft and especially its epithelial cells, as in the positive controls, was never observed, although the dose of deoxyribonucleic acid per mouse was comparatively large. This indicates that deoxyribonucleic acid by itself or with traces of bound proteins is insuffi-

Table 1

Material	Spectrum*		N/P*	No. of mice tested	Amount injected into one mouse (mgm.)	Result of transplantation immunity test on sixth day after transplantation†
	Min.	Max.				
Liver *A*	235	258	1·97	6	4·6	± − − − −
Liver *C*57	235	258	2·15	2	5	− −
Spleen *A*	235	258	2·07	4	0·77	± ± −
Spleen *C*57	230	258	1·95	2	1	− −
Spleen *A*	235	260	2·22	3	1·89	± − −
Spleen *C*57	230	258	1·72	3	0·4	− − −
Thymus *C*57	230	260	2·17	1	2	−
Thymus *C*57	230	258	1·72	2	0·4	− −
Control mice, not injected						
Test graft on normal non-injected mice				11	—	− − − − − − − − − − −
Test graft on mice previously immunized with tissue				7	—	+ + + + + + +

* Total nitrogen determined by the microkjeldahl method, phosphorus by the method of Berenblum and Chain. Solutions were measured in the ultra-violet range of the SF_4 spectrophotometer (U.S.S.R.).

† − reaction indicates appearance of epithelial cells and of the whole graft as on the sixth day after transplantation in first grafts on non-injected animals; ± reaction indicates part of the epithelium destroyed, pycnotic, vacuolized nuclei, signs of cellular reaction in the graft; + reaction indicates complete destruction of epithelium.

cient to produce transplantation immunity in homotransplantation. The causes of the weak reaction found in a few cases and the general antigenic activity of isolated tissue deoxyribonucleic acid are being further studied.

We wish to thank Dr. Kohoutová of the Biological Institute for supplying and testing the pneumococcal transformation factor.

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Experiments in this laboratory on the lines described above by Hašková and Hrubešová confirm their finding that preparations of deoxyribonucleic acid may provoke a feeble transplantation immunity that is detectable by homografts of skin. Splenic nuclear fragments from mice (usually of strain *A*) were washed six times in 0·15 *M* sodium chloride or in 0·15 *M* sodium chloride – 0·01 *M* sodium versenate at *p*H 7·0. Deoxyribonucleic acid was prepared from these nuclear fragments either by the sodium xylene sulphonate method (personally communicated by Dr. N. S. Simmons) or by dissolving them in 2 *M* sodium chloride, spinning at 25,000*g* for 30–60 min., and deproteinizing the supernatant by up to nine successive emulsifications with chloroform–amyl alcohol mixture[1]. The former preparation was completed by precipitation with 0·54 vol. *iso*propyl alcohol in the presence of 0·3 *M* neutral sodium acetate, and the latter by precipitation with 0·2 vol. ethyl alcohol in the presence of 0·15 *M* sodium chloride – 0·1 *M* calcium chloride[2]. In either case the fibres of deoxyribonucleate were blotted free from excess of fluid, cut up into coarse fragments under a balanced salt solution, and allowed to swell into stiff transparent jellies. In this form they were injected into recipient mice (usually of strain *CBA*), each mouse receiving about 5 mgm. deoxyribonucleic acid. The survival scores[3,4] at six days of test skin homografts transplanted three to five days after the injection ranged from 25 per cent (indicating a definite state of sensitivity) to 100 per cent (the normal or 'control' response). Great pains were taken throughout the preparations to ensure that the deoxyribonucleic acid was in an undegraded state.

Although other possibilities have been considered (including a transformation of host cells into cells with some of the antigenic properties of the donor) there is reason for believing that the feeble sensitivity provoked by these preparations was due to an antigenic impurity, probably of a polysaccharide nature. Recent evidence[5] suggests that the determinant groups of the antigens responsible for the homograft reaction (like those which are responsible for 'enhancement'[6]) may be mucoid substances: they are inactivated by exposure to low concentrations of the periodate ion and by incubation with extracts of *Trichomonas foetus* known to contain enzymes which destroy blood-group substances in man[7]. (The *Trichomonas* preparations were very kindly supplied by Dr. W. M. Watkins.) This interpretation is not inconsistent with the fact that 'transplantation' antigens are present in washed nuclear fragments[4] and follow the deoxyribonucleoprotein through at least the earlier stages of purification, for hexosamine is now known to be present as an impurity in even quite highly purified preparations of deoxyribonucleoprotein[6]. The nucleoprotein may possibly act as an adjuvant[8], if only by presenting the antigen in a physically suitable form, and the same may be true of the deoxyribonucleate when it is injected by the method described above.

Because of its relevance to a hypothesis of 'transformation', it may be added that the repeated injection into mice, from birth onwards, of high doses of undegraded homologous deoxyribonucleic acid failed in twenty-five trials to produce any sign of transplantation tolerance, that is, failed to prolong the life of skin homografts afterwards transplanted from mice of the same strain as those which provided the deoxyribonucleic acid.

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Influence of a Crude Hypothalamic Extract on the Acid Phosphatase Activity of Rat Pituitaries

In rat pituitaries incubated *in vitro* with hypothalamic extracts the ascorbic acid content falls. Extracts of other parts of the brain are less successful[1]. This experiment was used to confirm *in vitro* the earlier findings in intact animals that hypothalamic extracts are able to stimulate the release of several trophic hormones from the distal lobe of the pituitary[2]. In the present study we tried to use acid phosphatase activity as an indicator.

Fresh rat pituitaries were incubated in the Krebs-Ringer-phosphate medium for one hour, adding either a suspension of temporal lobe of the brain (mean weight 104 mgm.) or of the hypothalamic region, including the median eminence of the tuber cinereum and the walls adjacent to the third ventricle (mean weight 86 mgm.). Each pituitary was exposed to the influence of 1 ml. of suspension for 60 min. The surface of the pituitary was then dried, the gland homogenized and the activity of acid phosphatase estimated by the method of King and Armstrong (K.A.).

In the pituitaries of male rats the activity after incubation in the pure medium corresponded to 2·04 ± 0·168 K.A. units/gm. The addition of temporal lobe suspension to the medium yielded values of 2·08 ± 0·097 K.A. units/gm. The mean figures, however, for incubation with hypothalamic extract were 2·79 ± 0·175 K.A. units/gm., the difference being thus highly significant ($P = 0·01$). Acid phosphatase activity of the brain tissue itself has no influence on the results, since in the temporal lobe 1·21 ± 0·05 K.A. units/gm. was found, practically the same value being present in the hypothalamic region (namely, 1·19 ± 0·099).

These preliminary results do not permit conclusions to be drawn. It remains to be seen whether the acid phosphatase activity in the pituitary, incubated *in* *vitro*, can be utilized as a new tool in the study of the influence of hypothalamic extracts.

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Albinism in the Common or Hottentot Mole-Rat, *Cryptomys hottentotus* Lesson, 1826

DURING the past four years I have been compiling a preliminary list of the vertebrate fauna occurring in this National Park, situated in the Inyanga region of eastern Southern Rhodesia. During the course of these investigations it has become clear that the most common representative of the family Bathyergidae is *Cryptomys hottentotus* Lesson.

I am indebted to the assistant warden of the Park, Mr. Robert Reyers, for what would appear to be an albino specimen of this species, secured alive on April 19, 1958. This example is an adult male, with entirely white hair save in the region of the mouth and genital organs, where there is reddish discoloration from dietetic staining. The skin of the upper parts was bluish in life, and that of the under parts and feet, pink. The nails, except where suffused by blood, are white. In life the eyes were dark, with a faint suggestion of red, this latter becoming more apparent after death.

Roberts[1] lists a species *Cryptomys albus* (Roberts), the white mole-rat; and implies that he based his determinations upon three specimens, quoting (p. 398) these ". . . as the type and another specimen. There is also a buffy-yellowish specimen from Tulbagh". The distribution of this supposed species is given as "probably the Southern Cape Province only"; and attention is directed to the smaller size of the skull than in *C. hottentotus*.

The Inyanga specimen had the following measurements in life: Head and body, 125·0 mm. Tail, 12·0 mm. Hind-foot S.U., 21·0 mm.

Some skull measurements were as follows: length of skull with incisors, 37·5 mm.; zygomatic width, 24·0 mm.

The cheek teeth are simple, 4/4.

These figures come well within the range found among *C. hottentotus* secured at Inyanga, and also exceed those given by Roberts for the type of *C. albus*.

Ellerman, Morrison-Scott and Hayman[2] cite *C. albus* under the sub-heading *incertae sedis*, and Roberts mentions that Oldfield Thomas stated that the type of *C. albus* was an albino, a view shared by Ellerman, Morrison-Scott and Hayman (p. 234).

The Inyanga specimen was taken at approximately 6,000 ft. above sea-level and 32° 44′ E., 18° 17′ S.

Normal specimens of *C. hottentotus* at Inyanga are grey, darker upon the upper parts, and with a variable white head-spot which is sometimes vestigial.

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Change in Mean Viability at a Multi-allelic Locus in a Population under Random Mating

A MULTIPLE allelic series at a locus can give rise to genotypes of different viabilities. Under certain conditions these genotypes can exist in equilibrium in a large random-mating population.

Owen[1] has stated necessary and sufficient conditions for such an equilibrium (when it exists) to be stable for the case of three alleles, and in attempting to generalize these conditions to the case of n alleles and to derive reasonably concise and illuminating proofs we have been led to consider the change in the mean viability of the whole population from one generation to the next. We conjecture that the mean viability increases each time the population undergoes the process of mating, but to prove this statement generally appears to be a matter of considerable mathematical difficulty. However, it is of interest to show that this is the case at least when the population is in the neighbourhood of an (existent) equilibrium, since this is sufficient for the purpose of discussing the stability of the equilibrium.

Kimura[2] and Crow and Kimura[3] state that the change in mean fitness of a population is the ratio of its additive genetic variance to the mean fitness; this is the equivalent of Fisher's[4] fundamental theorem of natural selection. However, it can be shown that their result is not applicable to the case under discussion since its derivation depends on a continuous time argument. The application of their argument to the case of discrete generations can at best be an approximation, since it is valid only for the case of infinitesimally slow selection.

Consider n alleles $A_1, A_2, \ldots A_n$ at a single locus. Let a_{ij} denote the relative viability of the genotype $A_i A_j$ $(i,j = 1, 2, \ldots n)$, and let p_i $(i = 1, 2, \ldots n)$ be the frequency of gene A_i $(i = 1, 2, \ldots n)$ in any one generation. Let V be the mean viability of the population (supposed infinite and mating at random) in this generation, so that:

$$V = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij}\, p_i p_j \qquad (1)$$

Under random mating the frequencies p_i' of the alleles A_i in the next generation are given by the relations:

$$V p_i' = p_i \sum_{j=1}^{n} a_{ij} p_j \qquad (2)$$

The mean viability V' of the population in this next generation is:

$$V' = \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} p_i' p_j' \qquad (3)$$

What is required is a comparison of the values of V' and V, or, more precisely, to show that $V' - V > 0$.

Suppose now that a polymorphic equilibrium exists, and consider the population when it is in the neighbourhood of this equilibrium. Let P_i $(i = 1, 2, \ldots n)$ be the equilibrium frequencies and V_e the mean viability of the population at equilibrium. Then it can be shown that:

$$V_e = \sum_{j=1}^{n} a_{ij} P_j \quad (\text{all } i = 1, 2, \ldots, n) \qquad (4)$$

Let p_i be the gene frequencies in the neighbouring state and write:

$$p_i = P_i + x_i \quad (i = 1, 2, \ldots, n) \tag{5}$$

where the x_i are small and

$$\sum_{i=1}^{n} x_i = 0 \tag{6}$$

We also write

$$X_i = \sum_{j=1}^{n} a_{ij} x_j \quad (i = 1, 2, \ldots, n) \tag{7}$$

and

$$\delta = \sum_{i=1}^{n} x_i X_i \tag{8}$$

Then a short calculation (using (4), (5) and (6)) reveals that:

$$V = V_e + \delta \tag{9}$$

In the next generation the gene frequencies p_i' are determined according to equations (2) and, after some algebra, we obtain the following expression for V':

$$V' = V + \frac{2\delta^3 - 3\delta^2 V}{V^2} + \frac{2\,V_e}{V^2} \sum_{i=1}^{n} p_i X_i^2 + \frac{1}{V^2} \sum_{i,j=1}^{n} a_{ij} p_i p_j X_i X_j \tag{10}$$

Equations (4) and (5) are now used to express the difference $(V' - V)$ in terms of the P_i, X_i and V_e, together with an expression which is of higher degree than the second in the x_i, which will be denoted by $O(x_i^3)$; this yields

$$(V' - V)V^2 = V_e \sum_{i=1}^{n} P_i X_i^2 + \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} a_{ij} P_i P_j (X_i + X_j)^2 + O(x_i^3) \tag{11}$$

Thus, for sufficiently small values of the x_i (that is, when the population is near the equilibrium state), we have that $V' - V > 0$; hence the mean viability increases from one generation to the next.

Using this result, we can derive, in the form given by Owen, necessary and sufficient conditions for an equilibrium to be stable. These matters will be discussed in greater detail elsewhere.

One of us (S. P. H. M.) wishes to thank Dr. A. R. G. Owen for much helpful advice and encouragement; and the Royal Commission for the Exhibition of 1851 for the award of an Overseas Science Research Scholarship.

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Sexually Mature Individuals of *Xenopus laevis* from the Transplantation of Single Somatic Nuclei

A METHOD of testing the potentialities of nuclei from embryonic cells has been described by Briggs and King[1]. The method consists of transferring a nucleus from an embryonic cell into an enucleated and unfertilized egg of the same species. King and Briggs[2], who have performed their experiments on *Rana pipiens*, found that normal tadpoles resulted from eggs with transplanted nuclei in about 35 per cent of cases in which the nuclei were taken from blastulæ, but in only about 6 per cent of cases in which the nuclei were taken from late gastrula endoderm; they have not reported normal development from nuclei of post-neurulæ or later stages.

We have performed similar experiments on *Xenopus laevis*. In this species we do not enucleate the eggs, because the female pronucleus participates in the development of only a very few of the transplanted eggs; these cases can be recognized by the use of a nuclear marker[3], and are excluded from our results. The marker is introduced by taking donor nuclei from a stock of mutant individuals having only one nucleolus in all cells, as opposed to wild-type individuals in which all cells contain potentially two nucleoli. Large series of observations and measurements show no differences in the embryonic development, viability, growth-rate, and fertility between mutant individuals and their wild-type full sibs. The host eggs are taken from the wild-type stock and the female pronucleus introduces an additional nucleolar organizer when it participates in development. The origin of the nuclei in transplant-tadpoles can be interpreted with certainty by knowing the ploidy and number of nucleoli.

We have found that the great majority of normal tadpoles resulting from transferred nuclei pass through metamorphosis normally. The older frogs appear to be sexually mature males and females; the rate of growth and sexual differentiation is similar in transplant-embryos and controls. In order to test the capacity of gametogenesis in transplant-individuals, we hope shortly to breed from these. Immature oocytes were found in one transplant-frog which died two months after metamorphosis.

As with *Rana pipiens*, the proportion of normal development obtainable from transferred nuclei decreases with increasing age of the donor embryo. *Xenopus laevis* gives a smaller proportion of normal development from blastula nuclei than *Rana pipiens*, but on the other hand normal development can be obtained from much later donor stages; a pre-hatching tadpole (Nieuwkoop[4] stage 32, endoderm) was the most advanced stage of donor from which a normal individual was obtained, but this was accidentally killed shortly before metamorphosis. We have also a few frogs from nuclei which have been transferred twice (serial transfers).

Table 1 gives the numbers of metamorphosed frogs that have been obtained from different germ-layers and developmental stages of donor embryos. When transplanting endoderm nuclei from post-neurula stages care has been taken to avoid using nuclei from the region of the presumptive germ-cells.

When considering our results it is important to appreciate that the normal development of eggs with transferred nuclei may mean either that the nuclei were undifferentiated and totipotent, or that they

Table 1. METAMORPHOSED FROGS WHICH RESULTED FROM TRANSPLANTED NUCLEI

Donors			Transplants		
			Metamorphosed frogs		
Stage	Germ-layer	Total transfers	No.	Percentage of total	Percentage of normal late blastulæ
Mid and late blastula	Ectoderm	565	17	3·0	12
	Endoderm	159	12	7·5	16
Early gastrula	Ectoderm	94	7	7·5	40
	Endoderm	287	12	4·2	15
Late gastrula	Ectoderm	26	2	7·7	33
	Endoderm	185	11	5·9	16·5
Neural folds	Ectoderm	9	0	0	0 out of 1
	Mesoderm	325	4	1·2	6
	Endoderm	137	7	5·1	14
Tail bud	Endoderm	163	4	2·5	9
Muscular response	Endoderm	287	1	0·35	3
Pre-hatching tadpoles	Endoderm	357	0	0	0 out of 70
Total		2,594	77		

were differentiated, but were able to return to a totipotent state as a result of developing again in the cytoplasm of an uncleaved egg.

Our results may be summarized as follows: (1) It is possible to transplant nuclei without impairing their ability to bring about normal development. (2) Some nuclei are capable of giving normal development very shortly before the organ of which they are part becomes functional; normal development was obtained from presumptive somite nuclei nine hours before the first muscular responses. (3) Normal development results from nuclei of more advanced donor stages in *Xenopus* than in *Rana pipiens*. (4) A number of monozygotic frogs have been obtained from single donors.

It may now become possible to breed from our sexually mature individuals which have developed from single somatic nuclei, and to test their genetic qualities.

We gratefully acknowledge the technical assistance of Miss A. Jewkes. This work has been made possible by contributions from the British Empire Cancer Campaign (M. F. and T. R. E.) and the Medical Research Council (J. B. G.).

J. B. GURDON
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Department of Zoology and
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May 9.

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A Genetic Mechanism for 'Thread Protein' Polymorphism in Cattle

POLYMORPHISM in the 'thread proteins' of cattle sera has been described previously[1]. Four phenotypes have been found, depending on the presence or absence of one or both of a pair of threadlike zones, presumably proteins, resolved by starch-gel electrophoresis in phosphate buffer. The two zones are well separated, 'thread protein' T1 migrating more slowly than the *Sα* zone, and T2 more rapidly. Individuals with only a T1 zone (phenotype T1) are readily and consistently distinguished from individuals with only a T2 zone (phenotype T2). Samples taken from the same animal at intervals up to 18 months showed the same phenotypes as the initial samples. However, individuals with both T1 and T2 zones (phenotype T1/T2) or neither zone (phenotype T0) are not differentiated consistently, T1/T2 sometimes appearing as T0. Phenotypes T1/T2 and T0, therefore, are best considered as one phenotype (T*) in practice.

The numbers of offspring obtained from the six possible matings between the three distinguishable phenotypes are shown in Table 1. The results in Table 1 were obtained (*a*) from a large self-contained local herd of pedigree Friesians, and (*b*) from matings picked at random from Friesian herds in various parts of England. Consideration of the mating results suggested that 'thread protein' polymorphism in cattle is controlled by three autosomal genes T^A, T^B and T^O, so that zone T1 is seen in the presence of T^A and zone T2 in the presence of T^B, while T^O does not evoke the appearance of either 'thread protein'. Phenotype T1 is thus an expression of the genotypes T^A/T^A or T^A/T^O, phenotype $T2$ of the genotype T^B/T^B or T^B/T^O, while phenotype $T1$/T2 has the genotype T^A/T^B and the true phenotype T^O the genotype T^O/T^O.

Table 1. OBSERVED and EXPECTED MATING RESULTS IN BRITISH FRIESIANS

Mating (phenotypes)	No. of matings (observed/expected)	Phenotypes of offspring		
		T1 (obs./exp.)	T2 (obs./exp.)	T* (obs./exp.)
	A.	96 matings in self-contained herd		
T1 × T1	12/ 9·8	8/10·3	—	4/ 1·7
T1 × T2	14/20·4	4/ 3·3	5/ 3·3	5/ 7·4
T1 × T*	28/21·3	13/15·8	5/ 2·5	10/ 9·7
T2 × T2	5/10·7	—	4/ 4·3	1/ 0·7
T2 × T*	24/22·4	2/ 2·1	17/13·6	5/ 8·3
T* × T*	13/11·6	4/ 3·9	4/ 3·9	5/ 5·1
	B.	92 matings picked at random		
T1 × T1	7/ 5·7	6/ 5·9	—	1/ 1·1
T1 × T2	19/18·7	5/ 4·2	7/ 4·8	7/10·0
T1 × T*	18/15·7	6/10·0	2/ 1·6	10/ 6·4
T2 × T2	12/15·4	—	9/10·4	3/ 1·6
T2 × T*	30/25·8	4/ 2·6	19/17·3	7/10·3
T* × T*	6/10·8	1/ 1·8	3/ 1·8	2/ 2·4

T* = Combined phenotypes (T1/T2 + T0)

No. of matings: *A*, $\chi^2 = 7{\cdot}99$; $P > 0{\cdot}1$ (5 d.f.); *B*, $\chi^2 = 4{\cdot}25$; $P > 0{\cdot}5$ (5 d.f.).

Phenotypes of offspring: *A*, $\chi^2 = 10{\cdot}76$; $P > 0{\cdot}3$ (10 d.f.); *B*, $\chi^2 = 10{\cdot}41$; $P > 0{\cdot}3$ (10 d.f.).

The gene frequencies T^A, T^B and T^O can be calculated from the relationships $p = (T^A)^2 + 2(T^A \times T^O)$, $q = (T^B)^2 + 2(T^B \times T^O)$ and $r = (T^O)^2 + 2(T^A \times T^B)$, where p, q and r are the observed frequencies of the phenotypes T1, T2 and T*. These equations are readily solved on an electronic computer, and I am indebted to J. C. Gower, of Rothamsted, for calculating gene frequencies. The equations are satisfied by two sets of frequencies; the correct set can be chosen by examination of the mating results. From 213 animals in the local herd, p, q and r were found to be 0·320, 0·333 and 0·347 respectively, and the corresponding correct set of gene frequencies were T^A, 0·280, T^B, 0·290 and T^O, 0·430. From 184 cows, heifers and calves from the matings picked at random, p, q and r were 0·248, 0·408 and 0·343, giving T^A; 0·226; T^B, 0·338, and T^O, 0·437. Using these gene frequencies, the expected distribution of offspring in each set of data has been calculated and is shown in

Table 1. Also the expected number of each of the six possible matings has been calculated in each case and compared with the actual number found. It will be seen that the observed and expected distribution of offspring agree when tested by the χ^2 test, as do the expected and observed numbers of matings. The results presented in Table 1 therefore support the genetic mechanism proposed.

Although 'thread proteins' have been found in dogs and pigs[2], no evidence of polymorphism has been found in these zones in these animals, so far. The significance of 'thread protein' polymorphism in cattle is not clear at this stage.

There does not appear to be any correlation between the thread protein phenotypes and the six β-globulin cattle phenotypes described previously[3].

I wish to thank the Directors of Lord Rayleigh's Farms Inc., and Strutt and Parker Farms, Ltd., for permission to bleed cattle, and the veterinary officers of the Milk Marketing Board for collecting blood samples from A.I. (artificial insemination) herds.

G. C. Ashton

The Animal Health Trust,
Livestock Research Station,
Stock, Essex.
March 24.

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[1] Ashton, G. C., *Nature*, 180, 917 (1957).

[2] Ashton, G. C., *Nature*, 179, 824 (1957).

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Bones of a Vulture among the Remains of Animals sacrificed on the "Burial of Romulus" below the *Niger lapis* in the Roman Forum

In 1899 Giacomo Boni, director of the diggings in the Roman Forum, discovered, in the area of the *Comitium*, below the *Niger Lapis*, a layer containing votive bronze statuettes and sherds attributed to the sixth to seventh century B.C., and many fragments of bones, horns and teeth of *Sus*, *Ovis*, *Taurus*, *Capra* and *Canis*, obviously remains of a sacrifice[1]. This layer was enveloping the base of the '*sacellum*', a monument (including the famous archaic Latin inscription) which Giacomo Boni identified with the "*funestum locum in Comitio*" (Festus) which, following the Roman tradition, was supposed to be the burial of Romulus, or of his adoptive father Faustulus.

A recent revision of the skeletal remains of the sacrificial fauna collected in the above-mentioned layer by Giacomo Boni in 1899, and kept in Rome in the Antiquarium Forense (undertaken with the kind permission of Prof. P. Romanelli, "Soprintendente" to the Palatine and Forum), has led us to the identification of three fragments of bones of a vulture (Fig. 1). The fragments are: the distal part of a right humerus, with a small part of the diaphysis; the proximal part of a right ulna, with part of the diaphysis; another fragment of diaphysis of this latter bone. The three fragments belong to the same individual. The posterior face of the ulna shows two deep incisions, made on the fresh bone, by the knife of the sacrificer, when he cut the muscles of the fore-limb.

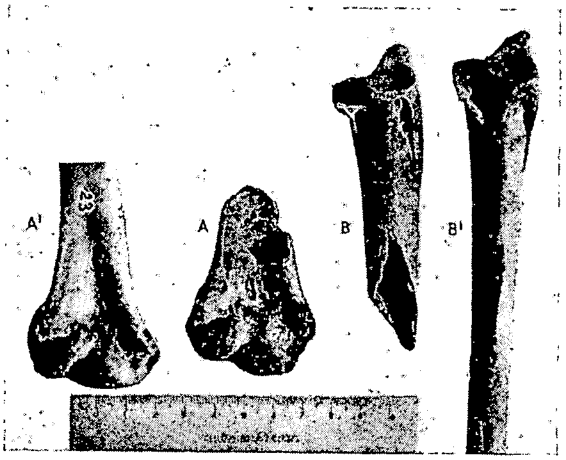

Fig. 1. *A*, distal portion of a right humerus, collected in 1899 by Giacomo Boni in the layer containing the remains of other sacrificed animals and archaic votive bronze statuettes and sherds of the sixth–seventh century B.C., underlying the *Niger lapis* in the area of the Comitium in the Roman Forum, now determined as *Vultur monachus* L. or *fulvus* Gmel. *A′*, distal portion of a right humerus of *Vultur monachus* L. (=*Aegypius monachus* (L.) Sardinia, Coll. Blanc. *B*, proximal portion of a right ulna collected in 1899 by Giacomo Boni, in the same layer as *A*, now determined as *Vultur monachus* L. or *fulvus* Gmel. *B′*, proximal portion of a right ulna of *Vultur monachus* L. (=*Aegypius monachus* (L.) Sardinia, Coll. Blanc

The morphology and the dimensions of the fragments indicate that they belong to a vulture of exceptionally large dimensions: either to the black vulture, *Vultur monachus* L.=*Aegypius monachus* (L.), or to the griffon vulture, *Vultur fulvus* Gmel.= *Gyps fulvus* Salvad. Owing to the extreme similarity of the osteological morphology and of the dimensions of these two species, and the fragmentary state of the bones examined, it has not been possible to reach a certain specific determination.

The vulture is a non-edible animal, difficult to capture, particularly in Roman times, and was protected by religious interdictions, being considered sacred to Mars and preferred to any other bird for taking omens.

Therefore the fact that a vulture was sacrificed, together with other victims, on the monument which was believed to be the burial of Romulus or Faustulus, should have an obvious relation with the story of the foundation of Rome, as reported by T. Livius and other classical authors. Romulus and Remus were said to have decided to settle their quarrel on where the new town had to be founded by watching the birds, believed to be the messengers of the gods. Remus watched from the Aventine Hill, Romulus from the Palatine. Remus is reported to have seen, first, the flight of six vultures, but Romulus is said to have seen twelve. Following Plutarch, Remus suspected a cheat, and moved towards his twin-brother. At that moment, Romulus really saw twelve vultures, and Remus had to accept the divine command revealed by the birds.

Titus Livius states that the first measure taken by Romulus as soon as he seized the power was to name twelve lictors, in remembrance of the twelve vultures which had announced to him the favour of the gods.

The tradition persisted for a long time, because, following P. Ovidius Naso, when Augustus became consul for the first time, he also saw twelve vultures, as was believed to have happened, seven centuries before, to the founder of Rome.

G. A. Blanc
A. C. Blanc

University of Rome.
May 20.

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FORTHCOMING EVENTS

Friday, July 11

Nutrition Society (at Queen Elizabeth College (University of London), Campden Hill Road, London, W.8), at 10.15 a.m.—Symposium on "Applied Nutrition: The Human Factor in Group Feeding".

British Psychological Society, Occupational Psychology Section (in the Department of Psychology, Birkbeck College, Malet Street, London, W.C.1), at 1 p.m.—Mr. Stephen Griew: "Methodological Problems in Ageing Research in Industry".

[Saturday, July 12

British Psychological Society (at Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. B. Delisle Burns (McGill University): "Memory and Amnesia".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Advisory Officer (with a degree in science or agriculture, preferably with honours, and experience in investigational and advisory work) in Animal Husbandry; and an Advisory Officer (with a degree in science or agriculture, preferably with honours, and experience in investigations or research concerning poultry husbandry) in Poultry Husbandry; and an Assistant Resident Supervisor (with a degree in agriculture and a special interest in animal husbandry) for Certificate Course in Agriculture—The Secretary, North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (July 10).

Metallurgist (L.I.M. or with the H.N.C. in metallurgy or physics) at the Research Laboratories, Leatherhead, Surrey, to assist in investigating unusual problems in the creep of metals used in nuclear power generation—Chief Personnel Officer, Central Electricity Generating Board, 24/30 Holborn, London, E.C.1, marking envelope "Confidential" and quoting Ref. N.167 (July 10).

Lecturer or Assistant, Grade B (with an honours degree) in Physiology or Pharmacology, for duties which include teaching and research—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (July 11).

Assistant (graduate in biochemistry) in Biochemistry in the Department of Child Life and Health—The Secretary, The University, Edinburgh (July 12).

Assistant Lecturer in Organic, Inorganic or Physical Chemistry—The Registrar, The Manchester College of Science and Technology, Manchester 1 (July 12).

Assistant Lecturer (with an honours degree in psychology and additional training or experience in clinical psychology) in Clinical Psychology in the Department of Psychiatry of the Faculty of Medicine—The Registrar, The University, Manchester (July 12).

Lecturer (with a good honours degree in applied mathematics or engineering science, and preferably research experience) in Civil Engineering—The Registrar, The University, Birmingham (July 14).

Lecturer in the Postgraduate Department of Applied Mechanics—The Registrar, The University, Sheffield (July 19).

Research Assistant in Mathematical Statistics in the Department of Applied Mathematics—The Registrar, The University, Liverpool (July 19).

Research Assistant in the Unit of Biometry, for duties mainly concerned with the design and analysis of radiobiological experiments in conjunction with the Agricultural Research Council radiobiological laboratory at Grove—The Reader in Biometry, The University, 7 Keble Road, Oxford (July 19).

Research Assistants (*a*) (with a good degree in biological science or physiology, and preferably some research experience or qualification) and (*b*) (with a good degree in chemistry or biochemistry and preferably some research experience or qualification), to investigate the effects of chemical pollutants on marine organisms—The Secretary and Registrar, The University, Southampton (July 19).

Head (with high academic qualifications and considerable statistical research experience) of the Statistics Section, Rubber Research Institute of Malaya, Kuala Lumpur, Malaya, for duties which will include the design of field and laboratory experiments and the conduct of research in statistical matters relating to all branches of the Institute's work—The Secretary, London Advisory Committee for Rubber Research (Ceylon and Malaya), Commonwealth Institute, Imperial Institute Road, London, S.W.7 (July 31).

Lecturer (preferably with special qualifications in applied mathematics) in Mathematics at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, July 31).

Research Assistant in the Department of Zoology and Comparative Anatomy, to join a small group studying problems of morphogenesis—The Secretary, University College, Gower Street, London, W.C.1 (July 31).

Lecturer in Mathematical Statistics at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 2).

Lecturer in Chemistry at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

Lecturer in Mathematics at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 20).

Assistant, Grade B (graduate, preferably with some previous teaching experience), for Mathematics, for duties which will involve work in degree and H.N.C. courses—The Clerk to the Governors, Mid-Essex Technical College and School of Art, Market Road, Chelmsford.

Assistant, Grade B (man), to teach theoretical and practical physics to B.Sc. General Degree students—The Clerk to the Governors, South-West Essex Technical College, Forest Road, London, E.17.

Assistant Lecturer (Grade B) in Mathematics—The Principal, Peel Park Technical College, Salford.

Assistant Physicist (with a first- or second-class honours degree and preferably previous experience) in the Radiotherapy Centre—The Medical Superintendent, St. Luke's Hospital, Guildford.

Cyclotron Radiochemist (with a good degree in chemistry and preferably some experience of radiochemistry), to take charge of the chemical aspects of radioisotope production for medical research, in collaboration with existing engineering and physics teams—The Director, Medical Research Council, Radiotherapeutic Research Unit Hammersmith Hospital, Ducane Road, London, W.12.

Lecturer in Mathematics, to teach up to B.Sc. General, Part II standard; and a Lecturer (preferably with industrial or research experience) in Chemistry, with special reference to inorganic chemistry—The Clerk to the Governors, Northern Polytechnic, Holloway London, N.7.

Lecturer or Assistant Lecturer (preferably with an interest in physiology and ecology) in Botany at Makerere College, The University College of East Africa—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1.

Lecturer or Senior Lecturer in Metallurgy in the Department of Mechanical Engineering—The Principal, Royal Technical College, Salford.

Lecturers in Mathematics—Professor D. B. DeLury, Department of Mathematics, The University, Toronto.

Physicist or Physical Chemist (with a first- or good second-class honours degree, and preferably with previous biological research experience), to work on adhesion in relation to wound dressings—The Secretary, Department of Biomechanics and Surgical Materials, Institute of Orthopædics (University of London), Royal National Orthopædic Hospital, Brockley Hill, Stanmore, Middlesex.

Research Physicists (2), to work on problems concerned with (1) X-rays and radiation dosimetry and (2) the development and application to medical research of a tritium counting apparatus—The Director, Medical Physics Unit, University of Edinburgh and South-Eastern Regional Hospital Board, 12 George Square, Edinburgh 8.

Senior Control Officer (Tsetse) (aged between 30 and 45 and with at least five years experience on tsetse control work, and able to handle large gangs of labour) with the Government of the Northern Region of Nigeria—The Crown Agents, 4 Millbank, London, S.W.1, quoting Ref. M.3A/44848/TA.

Senior Scientific Officer or Scientific Officer (with a first- or second-class honours degree in physics or engineering or equivalent, and preferably a knowledge of work involving high pressure fluids. miniature precision mechanisms, strength of materials or metal physics) in the Mechanical Engineering Research Laboratory (D.S.I.R.), Plasticity Division, East Kilbride, Glasgow, to take charge of a team working on high pressure physics—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. A.226/8A.

Senior Scientific Officers and Scientific Officers at Ministry of Supply Research and Development Establishments mainly in the southern half of England, for work in physics, electronics, electrical or mechanical engineering, applied mathematics, chemistry or metallurgy—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.182/8A.

Senior Scientific Officers (2) (with a first- or second-class honours degree in science or engineering and at least three years postgraduate experience) at the Headquarters of the Department of Scientific and Industrial Research, London, S.W.1, for scientific administrative duties—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.229/8A.

Senior Scientific/Scientific Officers (with at least a second-class honours degree in chemistry, and for one of the posts physical chemistry or applied physics experience or qualifications would be an advantage), to join a team of chemists and chemical engineers making fundamental and applied research studies in the organic chemical field, covering investigations on preparative methods of specialized materials, and physico-chemical problems arising from production and research programmes—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. 187/34.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Proceedings of the Royal Irish Academy. Vol. 59, Section A, No. 1: A Model in General Relativity for the Instantaneous Transformation of a Massive Particle into Radiation. By J. L. Synge. Pp. 1–14. 2*s*. 6*d*. Vol. 59, Section A, No. 2: Fermi Coordinates. By L. O. Raifeartaigh. Pp. 15–24. 2*s*. Vol. 59, Section B, No. 1: The Aureole Rocks of the Leinster Granite in South Dublin, Ireland. By J. C. Brindley. Pp. 1–18. 2*s*. Vol. 59, Section B, No. 2: A Quaternary Succession at Sutton, Co. Dublin. By N. Stephens and F. M. Synge. Pp. 19–28+plates 1 and 2. 2*s*. Vol. 59, Section B, No. 3: An Ecological Study of Two Areas of Blanket Bog on the Galway-Mayo Peninsula, Ireland. By D. J. Boatman. Pp. 29–42. 1*s*. 6*d*. Vol. 59, Section B, No. 4: The Periodate Oxidation of 3-*O*-Methylglucose and 2-*O*-Methylarabinose. By P. W. D. Mitchell. Pp. 43–52. 1*s*. 6*d*. Vol. 59, Section B, No. 5: Salmon of the River Lee, 1944 and 1956. By Hazel W. Newman. Pp. 53–70. 3*s*. Vol. 59, Section B, No. 6: Desmids from the Plankton of Some Irish Loughs. By A. J. Brook. Pp. 71–92. 3*s*. (Dublin: Hodges, Figgis and Co., Ltd., 1957 and 1958.) [284

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BROADCASTING AND TELEVISION

IN the past ten years the number of television licences in Britain has grown from less than 15,000 to nearly eight million, and the estimated number of adults aged sixteen or more in homes with television sets from 80,000 (all in the London region), which was 0·2 per cent of the total adults, to 21,850,000 or 57·9 per cent. For every person who had a television set in 1947 there are five hundred to-day, and six out of ten adults can see television in their own homes. An admirable broadsheet issued by Political and Economic Planning* sets out some of the facts behind this remarkable expansion, the characteristics of the television public and the development of commercial television and of public attitudes towards it. It attempts no critical judgments, but indicates some of the problems that accompany this rapid entry of television into the lives of millions of people, and more especially it gives a broad picture of the position of television in the economic life of the community in Britain.

Experiments in television broadcasting began in Britain in the autumn of 1929, and the world's first public television service was started by the British Broadcasting Corporation from Alexandra Palace in November 1936. When the service was closed down at the outbreak of war in 1939, there were still little more than 20,000 television receivers in Britain, and although the service was re-opened in June 1946, until 1949 it covered only the London area, and in March 1949 there were still only 127,000 licence holders. The eighteen B.B.C. transmitters now in operation cover about 98 per cent of the population, while 75 per cent are covered by the six transmitters of the Independent Television Authority, and this will be increased to 85 per cent with the opening of the Central Southern and North-East England stations later this year. By 1959–60, the Independent Television Authority hopes to have eleven stations in operation, covering about 90 per cent of the population.

Most of the television sets now in use in Britain have 14-in. or 17-in. tubes; but although screens are very much larger than they were ten years ago, the average size of a set is still smaller than in the United States. Retail sales of television receivers in Britain are estimated at 1,439,000 in 1957 at an average price of £75 18*s*., including purchase tax at 60 per cent, and about 50 per cent of retail sales during the past two years have been by hire purchase or credit transactions. Rented sets may possibly exceed half a million, and the number of new subscribers to television relay services in 1957 is put at more than 80,000.

The United Kingdom now ranks third with Canada in its ratio of persons to television receivers (6); only the United States (4) and Hawaii (5) exceed it. For Europe, Monaco (10), Belgium (45), Denmark (45), West Germany (55), Netherlands (56), U.S.S.R. (67), France (72) and Italy (78) are the only countries having ratios of less than 100. There are more television receivers in operation in the United Kingdom than in any other country except the United States, and with 55 hr. of weekly transmission the United Kingdom has double the hours of viewing of any other European country except Italy (45), France (41), Poland (39), Spain (32) and the U.S.S.R. (32), though far exceeded by the United States (133) and Canada (91). There are now more people in Britain with licences for television than for sound alone, and since 1953 the number of television licence holders has been increasing by 1·2 million each year; it is estimated that in February 1957, 36 per cent of all adults were able to receive both B.B.C. and I.T.V. transmission in their homes, and another 23 per cent B.B.C. transmission only.

The nature, as well as the size and geographical distribution of the television public, have been steadily changing since the Second World War; and while, ten years ago, in terms of social class, the upper 12 per cent had nearly half the total number of sets in use and the bottom 68 per cent only a quarter of the total, there is now little to distinguish the television public from a representative cross-section of the public in this respect, namely, one-quarter middle class and three-quarters working-class. There is also probably little to distinguish the television public from a cross-section of the public in respect of occupation and education. Households with television, however, are on average larger than those without. During the last quarter of 1957 the average evening sound audience of 3,650,000 was less than half as great as the average evening television audience of 7,400,000.

To judge of the effect of the contents of television programmes on the public would require a much more searching inquiry than P.E.P. has attempted for this broadsheet, but the comparison between the programmes of the Independent Television Authority and the British Broadcasting Corporation presents some indication that the latter has regained some ground lost initially. Nor is the effect of advertising clearer, though the growth of television advertising expenditure from some £2 million in the last quarter of 1955 to nearly £32 million in 1957 is noteworthy and is estimated at about 11 per cent of all advertising expenditure, compared with 4·5 per cent in 1956. Primarily such advertising is concerned with mass-market goods, for which the unit of purchase is small. The broadsheet concludes, however, that it is impossible to say to what extent the Press has suffered from the competition of television advertising, because the slackening in the rate of growth of total Press advertising revenues may be due to many factors unconnected with television.

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* *Planning*, Vol. 24, No. 420 (24 March, 1958): Television in Britain. Pp. 37–68. (London: Political and Economic Planning, 1958.) 3*s*. 6*d*.

The magnitude of the economic impact of television is well summarized in the concluding section of the broadsheet. Of consumer expenditure on the provision and maintenance of television receivers, excluding licence fees, estimated at about £150 million in 1957, £109 million represents the purchase of new television receivers; £25 million the servicing of existing sets; aerials, tables, etc., £6 million; and rented sets, £12·5 million. The cost of licences to the consumer amounted to about £18 million, including £2 out of the £3 combined receiving licence which is allotted to television and an allowance for the £1 excise duty payable for only part of the year. The total £170 million is the equivalent of less than 1·3 per cent of all consumer expenditure at market prices. Television advertising expenditure, from which the independent television service is financed, approached £40 million, including production costs, and the Exchequer revenue from purchase tax on television receivers was perhaps £31·5 million. The £1 excise duty payable on television licences will yield £8 million or more in a full year, and in 1957 the Exchequer received about £15 million from the B.B.C. licence revenue.

Nevertheless, while it could be questioned whether Great Britain can afford to put into television capital expenditure of the magnitude of the post-war years, having regard to other demands for capital development, notably in transport and roads, the economic impact may well be insignificant compared with the social effects. The evidence presented in the P.E.P. broadsheet alone suggests that the standard of living in Britain is notably higher than in other European countries, or at least that the British people prefer to put expenditure on television before other expenditure that might raise standards of education, for example. It will not always be easy, in the light of this broadsheet, to counter some of the arguments which we may meet in advancing our own proposals for European Free Trade.

Apart from that, the broadsheet puts a rather different complexion on the debate regarding competitive television and the relations between broadcasting and television which preceded the establishment of the Independent Television Authority and that about the fourteen-day rule, whereby topics to be discussed in Parliament must not be raised during the previous fortnight. The broadsheet does not throw much light on the question whether television is a drug or a stimulant, and it scarcely touches the distinctive qualities of television as a medium. Nevertheless, it indicates the immense potentialities of television—and broadcasting—for informing the public mind and even moulding public opinion, and by implication the desirability of ensuring that public discussion of vital issues is as full and early and also as uninhibited as possible. It is a vital public interest that no irrelevant traditions, even of Parliament, should allow prejudices to be formed and mistaken ideas to be disseminated through an obsolete time schedule; and the replacement of the fourteen-day rule by a seven-day embargo, with most of the limitations lapsing after the second reading of a Bill recommended by a Select Committee of the House of Commons, was a sensible proposal.

It is perhaps premature to judge how far television can be a stimulant, particularly from an informative or educational point of view, without much wider inquiry into the potentialities of television as a medium. In the meantime, the evidence that it does sometimes act as a drug should induce positive action to offset secondary effects which might well be serious and could also create difficulties in the use of television for positive purposes. Published evidence as to the effect of television on social habits and hobbies does not indicate a wide difference between the habits of those owning television sets and those without, in many activities such as sport, gardening, theatre-going and card-playing: the most significant differences appear in reading, attendance at the cinema, church-going and dancing.

Certain activities have been greatly affected by the growth of television; but even so, except for reading, it could perhaps be argued that television could contribute something to offset any loss. A recent thoughtful article on the B.B.C. Third Programme and its relation to broadcasting by Dr. M. B. Counan in the *Universities Review* of February indicates the nature of such reactions and the need for forethought as to the consequences. Dr. Counan does not conceal his belief that the introduction of competitive television was an error of judgment, and urges that we should seek to secure the removal of the present B.B.C. Charter in 1962 or even to reinstate the B.B.C. monopoly. The main interest of his article, however, lies, first in its clear statement of the cultural contribution of the Third Programme, and then in its equally clear analysis of the way in which that contribution has been diminished by the failure to develop and improve it continually and to provide it with sufficient finance and time.

The latter is the vital point, for although *vis à vis* Independent television there is evidence that the B.B.C. has regained some ground, as already noted, this does not apply to sound broadcasting, and what is happening there can happen in other fields also if no effort is made to avert such consequences. As Dr. Counan observes, the influence of the B.B.C. on the cultural life of Britain must diminish even if no further changes are made. Competition with the commercial service for talent and copyright inevitably raises costs and will lead the Corporation to seek a larger licence fee. Such uncertainties, coupled with the knowledge that it is losing ground with the public, make for a lack of confidence and insecurity within the Corporation which is reflected in its programme policy.

What emerges from these preliminary inquiries is the urgent need for more objective thinking and searching, disinterested inquiry into the indirect as well as the direct effects of broadcasting, both sound and television, upon our social life and institutions. That they have immense power, both for good and for evil, over the lives and minds of men and women is widely recognized; but as yet we know relatively little about how to use that influence constructively, even in education. Meanwhile, there is danger that, apart from their destructive effect upon certain habits and institutions that make for stability and coherence in our social life, those influences may set the minds of men and women in ways which make it even more difficult to achieve the constructive possibilities. To counter that, it is the more important that the utmost use should be made of the opportunities which exist in broadcasting at present, either through the Third Programme or other programmes, of creating, possibly in co-operation with the Press and other means, an informed public opinion which is essential if policy is to be formed and action taken in fields such as defence, education, health or trade. To that end informed public discussion of current issues is a vital contribution.

THE LIFE OF DARWIN

The Autobiography of Charles Darwin, 1809–1882

Edited by Nora Barlow. Pp. 253 + 4 plates. (London: William Collins, Sons and Co., Ltd., 1958.) 16*s*. net.

LADY BARLOW keeps adding to our debt of gratitude for her untiring care in editing or de-editing the literary remains of her illustrious grandfather.

It is good to have Charles Darwin's original biographical sketch as it was written and left for the information of his children and grandchildren "with original omissions restored". His grand-daughter's notes are helpful and informative, and do not trouble or interrupt the narrative.

About half the book is, however, devoted to new material. There are two appendixes, one of eighteen pages "On Charles Darwin and his grandfather Dr. Erasmus Darwin", and one of more than fifty entitled "The Darwin–Butler Controversy". The six notes which complete the volume are of personal and bibliographical interest, and take only twenty-six pages.

The relationship between Charles Darwin's evolutionary doctrine and that of Erasmus Darwin is treated here in terms of the theories, if that is not too strong a word, held by Charles on the subject of scientific inference. I believe this point of view does less than justice to his grandfather, who wrote in the tradition of didactic poetry, and was, to the taste of his century, one of the greatest of poets. I do not understand that this fact should be ignored merely because, eighty years later, the function of poetry in contemporary literature had changed; and people like Coleridge had written spitefully.

The charge that Charles plagiarized his grandfather's work, and took credit for his ideas, was indeed nothing but a malicious falsification due, I suppose, to Samuel Butler relying on the public's lack of direct familiarity with the work of either. I could wish that Lady Barlow had given half a dozen pages in this first appendix to quotations from "The Botanic Garden" and from the "Zoonomia". The sonorous lines could be annotated from Buffon or Lucretius, lest the reader forget that Erasmus as an eighteenth century *philosophe* was expressing his appreciation of an old and richly poetic idea and not assembling the evidence for an inductive proposition. It would be apparent that Erasmus was not trying to do what his grandson later did, and this not from any lack of understanding of the proper procedure of the natural sciences.

I have, for myself, no doubt that Charles would never have undertaken the large task of marshalling the evidence for "descent with modification", which had indeed become much more impressive since Erasmus's time, without having hit upon a truly naturalistic explanation. Speculation, indeed, has an important part to play in inductive reasoning, but speculation supported by a theory which both Cuvier and Lyell had been forced to reject was to Charles Darwin a major obstacle.

R. A. FISHER

FOOD AND POPULATION

The Grassland and Fodder Resources of India

By R. O. Whyte. (Scientific Monograph No. 22.) Pp. v + 437 + 50 plates. (New Delhi: Indian Council of Agricultural Research, 1957.) Rs. 16; 36*s*.; 5 dollars.

IT has been realized for many years that the grazing and fodder resources of India are inadequate to meet the needs of the livestock population and through them the nutritional requirements of the Indian people. This volume, published by the Indian Council of Agricultural Research, reviews our present knowledge of the extent and use of these resources. The author, who is agronomist with the Food and Agriculture Organization of the United Nations, has worked in close collaboration with Indian grassland specialists for the past five years.

In India, most of the livestock is kept in the villages, and although the working animals and buffaloes are hand-fed to some extent, the cows and young stock suffer severely from malnutrition. The village grasslands are heavily over-stocked, and although they can be regenerated by controlled grazing, even then they can supply keep for only four to five months of the year. The improved herbage does not provide adequate nutrition for high-quality cattle, such as dairy cows, which require supplementary fodder rich in protein. The use of sown leys is precluded in most areas by the large and increasing human population, all the cultivable land being of necessity devoted to food and cash crops with a few annual fodder crops.

The author suggests that the most effective increase in livestock production can be obtained by controlled management of the village grasslands, based on a knowledge of their position in the ecological succession to forest, and supplemented by the conservation of fodder for the dry season, and the use of annual leguminous fodder crops.

In practice, however, these recommendations raise serious religious and social difficulties. The optimum carrying capacity of most village grasslands is far lower than the present livestock population, but the strong religious objection to killing old and surplus cattle makes the necessary reduction in numbers rather improbable in the near future. Furthermore, the small size and fragmented nature of the holdings prevent adequate provision of supplementary fodder. To maintain a family and their necessary animals requires over five acres of irrigated land, and considerably more of dryland, yet over most of India 60 per cent of the holdings are less than five acres.

These problems are social and religious rather than purely technical, and their solution depends on the informed education of the agricultural student and adviser, and through them of the farmer himself. For this purpose the present book is an admirable source of balanced and reliable information, and may well serve as a standard text-book on Indian grassland husbandry.

The standard of production, though not high, is serviceable and the price reasonable. Many of the illustrations of grassland types leave much to the imagination, and the legends on the map of soil types require a strong magnifying glass, but these are minor blemishes on a most timely and useful publication.

J. P. Cooper

PHYSIOLOGICAL ECOLOGY

The Water Relations of Terrestrial Arthropods

By Prof. E. B. Edney. (Cambridge Monographs in Experimental Biology, No. 5.) Pp. vi+109. (Cambridge: At the University Press, 1957.) 15*s*. net.

NATURALISTS have for a long time been aware that insects and many other arthropods live under conditions which often expose them to the danger of considerable desiccation. Physiologists have, in the laboratory, studied the effects of temperature and humidity on these animals, and have discovered mechanisms which enable them to survive under what would appear to be unfavourable conditions. In this book Prof. Edney has brought together the results of these laboratory investigations in such a way that ecologists will be able to find many explanations of their field observations.

Insects, and some other arthropods, are the only 'small' animals which are not either aquatic or restricted to an environment where the air is normally saturated. They are able to live under these conditions because they have a more-or-less waterproof cuticle, and because they have respiratory mechanisms which enable them to take in sufficient oxygen and lose a corresponding amount of carbon dioxide without also losing an excessive quantity of water. There are, of course, limits to the efficiency of these processes, and it is probably the need to respire which finally limits the distribution of many insects. We have known for twenty-five years that, of the water which is evaporated from insects, particularly those adapted to dry environments, practically all is lost through the respiratory spiracles, and scarcely any through the general surface of the cuticle, but a full elucidation of the nature of this cuticle, and the reasons for its remarkable properties, has taken a long time, and work is still proceeding. Prof. Edney devotes nearly a third of his text to an admirable account of our present knowledge of this subject, and he makes it as easy to understand as is possible when dealing with such an essentially complicated subject.

The second way in which these animals withstand dry conditions is by having developed excretory mechanisms which function with the minimum loss of water. Not only have they evolved means of eliminating waste nitrogen in insoluble forms (uric acid, guanine) which can be voided without any substantial loss of water, so that the urine is often practically solid, but also many have complicated mechanisms which cause the fæces also to be bone-dry. These mechanisms cannot, however, prevent considerable fluctuations in water content and in the concentration of salts and other substances in insect tissues. The ability of the insects to function normally while these changes are taking place is a further important reason for the success of the group in colonizing such a wide range of habitats. It may seem surprising to find that five pages of this short book of only 93 pages of text on terrestrial arthropods are devoted to osmotic regulation in aquatic forms, but the work described here is clearly relevant to the main argument and its inclusion is fully justified.

The ways in which arthropods gain water is also discussed. Considerable space is devoted to the interesting, and still unsolved, problem, of how some arthropods take up moisture from unsaturated air. This problem, though interesting to the physiologists, is of only minor importance in ecology, and it would perhaps have been better to have devoted more attention to the commoner methods by which water is gained. It is surprising, for example, to read that "drinking of liquid water—is confined to adults; larvæ obtaining their water with the food". The naturalists who preceded the present generation of ecologists were familiar with the way in which caterpillars would drink, and one species, the drinker caterpillar, was particularly well known in this connexion. This is, however, only a minor point, and it is very satisfactory to find the sometimes controversial question of metabolic water so clearly dealt with.

The body temperature of small animals is normally very close to that of the atmosphere, but may be higher due to insolation, and lower due to evaporation. Such cooling is relatively uncommon as it leads to desiccation, but Prof. Edney himself has shown that in woodlice it may not be unimportant. As a whole these animals supplement the physiological mechanisms by their behaviour; they can not only withstand some exposure to unfavourable conditions, they are also able to react in such a way as to find the least unfavourable positions within their environment.

Kenneth Mellanby

THERMO-ELECTRIC POWER

Semiconductor Thermoelements and Thermoelectric Cooling

By A. F. Ioffe. (Translated from the Russian.) Pp. vii+184. (London: Infosearch, Ltd., 1957.) 42*s*.; 6 dollars.

IN the early years of this century the possibility of using the thermo-electric effect to produce electrical power was explored. The idea was abandoned because of the relatively small thermo-electric powers of metal junctions. The more recent development of semi-conductors with controlled constitution and physical characteristics has caused a revival of interest in the thermo-electric generator and also in the use of the Peltier effect to provide a refrigeration unit, since semi-conductor junctions provide relatively large thermo-electric powers. In the present book Prof. A. F. Ioffe has combined two other works, one on the basic theory of thermojunctions and the other on application of thermojunctions to refrigeration. In his Institute for Semiconductors of the Soviet Academy of Sciences considerable effort has been given to the development of efficient semi-conductor thermo-elements, both for power generation and for refrigeration. It is clear from the text that the Institute is fully aware of the basic problems involved and has made progress which compares very favourably with that in Britain and the United States.

In the first part of the book, following a brief historical introduction, the author presents the fundamental theory of the various thermo-electric effects and gives special attention to the problems raised by the different statistics of degenerate and non-degenerate semi-conductors. He then gives the important criteria for efficient thermojunctions and finally derives the well-known efficiency factor which is the square of the thermo-electric power divided by the product of thermal conductivity and electrical resistivity. In giving the conditions for optimum performance the text provides a very useful discussion of the influence of such effects as phonon and impurity scattering of charge carriers. As regards experimental material, mention is made of the PbSe–PbTe and the Bi_2Te_3–Sb_2Te_3 series as sources of efficient semiconductors for thermo-electric devices.

To some extent the combination of two books produces repetition of material from the first part in the second part of the text; for example, the efficiency factor is re-presented. The second part includes an interesting summary of the experimental studies made on the selenides and tellurides mentioned above. As shown by other workers in the West, the principal problem is to prepare semi-conductors with suitable impurities so that a reduction in the thermal conductivity is obtained without a corresponding decrease in electrical conductivity.

In the last chapter of the book interesting examples of practical refrigerator units are given, while elsewhere examples of power generators (one suitable for mounting over a paraffin-lamp glass for supplying power to a radio set) are included. Although n-type PbTe–PbSe combined with p-type Sb_2Te_3 appears to be the junction used in many refrigeration units, there is a noticeable absence of specification of the junction used in the later developments where a temperature difference of 70° C. is claimed between hot and cold junctions.

On the whole, this book is a very welcome addition to the relatively sparse collected literature on semiconductor thermo-electric devices. It is lucidly written and shows an appreciation of the contemporary position in the West at the time of writing. It is to be hoped that more translations of Russian texts on solid state physics will quickly follow this one.

G. F. J. Garlick

ELECTRICAL PROPERTIES OF MATERIALS

Handbuch der Physik

Herausgegeben von S. Flügge. Band 17: Dielektrika. Pp. vi+406. 94 D.M. Band 19: Elektrische Lietungsphänomene I. Pp. vi+411. 82 D.M. Band 20: Elektrische Leitungsphänomeme II. Pp. vii+491. 112 D.M. (Berlin: Springer-Verlag, 1957.)

The three volumes in question are concerned with the theoretical physics underlying the electrical properties of materials, some of which have great technological importance. In general, the aim of the editors is to cover the theory as completely as possible, but several of the articles cater for the experimentalist who is looking for physical meaning, as well as for the pure theoretician. The bibliographies given seem up to date to 1955 or 1956; as a small point of criticism it may be mentioned that there is no consistent policy as to whether references should be given in footnotes or collected at the end of each article. Some articles are in English, some in German, and one is in French. The general index at the end of each volume is given both in German and English, with translations. The printing of the mathematical formulæ is of a luxurious standard.

Volume 17 contains three articles of about equal length. The first, on "Dielectrics", by W. Fuller Brown, covers the theory of the static dielectric constant and dielectric loss. The author gives a somewhat cumbersome text-book presentation of the subject with the emphasis on formal electrostatics. There is a short section on recent work on microwaves. The article on "Electrical Breakdown", by W. Franz, in German, contains a historical survey of the subject which is somewhat out of date on the technological side, and chapters on thermal and intrinsic breakdown. The main interest of the article lies in a discussion of the different theories of intrinsic breakdown, given with a fair amount of mathematical detail. The article on "Piezoelectricity, Electrostriction and Ferroelectricity", by P. W. Forsberg, unifies its three subjects on the basis of a treatment by tensors. This presentation leads to a certain amount of repetition, but the article reviews much recent material, and contains a wealth of beautiful illustrations.

Volume 19 is written wholly in English. J. C. Slater contributes an article on "The Electronic Structure of Solids" which introduces the reader to a subject which is the basis of a large part of Volumes 19 and 20. The article is chiefly concerned with the theory of electrons in a periodic lattice in terms of the band model, and contains sections also on cohesive energies and elastic properties and on magnetism. The author frequently includes discussions in non-mathematical terms particularly where the physical meaning of approximations is concerned. The second article, by A. N. Gerritsen, "Metallic Conductivity, Experimental Part", concentrates on work after 1945. The article covers metallic conductivity as a function of physical parameters and of crystal structure and imperfections, and contains many tables and graphs. H. Jones contributes an advanced and condensed treatment of the "Theory of Electrical and Thermal Conductivity in Metals". In particular, he gives chapters on conductivity at low temperatures and the anomalous skin effect, and he treats *Umklapp* processes more fully than usual. G. F. J. Garlick, in an article on "Photoconductivity", gives a relatively short theoretical introduction and proceeds to give a tightly packed review of post-war work, largely experimental. There is little overlap between this article and the article on semiconductors in Volume 20.

About half of Volume 20 consists of an article on "Semi-conductors" by O. Madelung, in German. This is theoretical, with the emphasis on statistical thermodynamics, but the presentation caters for the experimentalist. About 100 pages are devoted to the theory of homogeneous semi-conductors in and out of equilibrium, with the emphasis on electrical conduction, while some 30 pages deal with p–n junctions, leading logically to the theory of transistors. Surfaces and contacts are also discussed, and the author gives a summary of the experimental methods for the determination of the most important parameters of semi-conductors. Optical and magnetic properties are only touched on. The article on "Ionic Conductivity", by A. B. Lidiard, in English, is also theoretical with the emphasis on statistical thermodynamics and physical meaning. It gives an integrated picture of a subject the references to which are otherwise widely scattered. The author discusses intrinsic and structure-sensitive conductivity, and gives a section on alternating-current phenomena which is incidentally of dielectric interest. J. M. Stevels, in a comprehensive article in English, reviews the electrical properties of glass. He takes the structure as read and treats dielectric properties and electrical breakdown as well as electrical conduction. For the last article there is a change in physical imagery as well as in language, since the subject is concerned with liquids instead of solids, and the language happens to be French. E. Darmois, in an article on "Electrochemistry", gives a fairly comprehensive introduction to the theory of electrolytes and then reviews such less accessible subjects as electrocapillarity, the theory of the double layer, and electrokinetic phenomena.

CONTRIBUTION OF RADIOBIOLOGY TO GENERAL BIOLOGY

Symposium on Antibodies

Their Production and Mechanism of Action. (Given at Research Conference for Biology and Medicine of the Atomic Energy Commission. Sponsored by the Biology Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee; held at Gatlinburg, Tennessee, April 8–10, 1957. Reprinted from the *Journal of Cellular and Comparative Physiology*, Vol. 50, Supplement 1, December 1957.) Pp. x+361. (Philadelphia: The Wistar Institute of Anatomy and Biology, 1957.) n.p.

THE biological changes produced by ionizing radiations began to be studied immediately after Röntgen's discovery of X-rays, but it is only in the past fifteen years that the research effort put into radiobiology has really gained momentum. The dividend reaped has extended far beyond original expectations, and this applied research has contributed very greatly to the progress of general biology. It is a good illustration of how fundamental discoveries can spring from researches directed to a more immediate and practical end.

The annual research symposia organized by the Oak Ridge National Laboratory since 1947, on a wide range of biological topics, have played an important part in making radiation studies an integral part of contemporary biology. The subjects chosen have shown a great awareness of the trend the researches are taking and have brought together experts just at a time when the particular subject was advancing rapidly. As an example the seventh conference of the series, in 1954, may be mentioned. It dealt with genetic recombination from different aspects, and by doing so synthesized our observations on bacterial transformation and transduction and stimulated the measuring of genetic distances in molecular dimensions. This particular conference applied the Watson-Crick model of deoxyribonucleic acid on the chromosomal level, and developed new concepts which have helped considerably in the analysis of various problems of cytology and genetics. In some of the symposia, such as those on genetics, the influence of radiation formed an integral part of the topic discussed; while in others, such as those devoted to the biochemistry and biophysics of important macromolecules, radiation did not enter into the main papers at all though its relevance to the subject was brought out in the well-edited discussion.

The tenth meeting, held in April 1957, and published like all the others as a supplement to the *Journal of Cellular and Comparative Physiology*, is typical. Its subject: "Antibodies: their Production and Mechanism of Action", provided an excellent forum for the discussion of the interesting problems which arose in connexion with the application of a new method, for enhancing, and in certain instances achieving, the complete recovery of experimental animals from radiation injury. The method, first suggested by the observation of Lorenz and his collaborators in 1951, consists of the transplantation of blood-forming tissues such as the bone marrow, into animals whose hæmopoietic organs are destroyed by irradiation, and has been intensively studied in many laboratories. Progress has been rapid, particularly since 1955, when D. L. Lindsley and his colleagues (Oak Ridge) demonstrated, by using genetic markers which differentiated between host and donor, that the transplanted donor tissue took over the function of blood formation. The cytological proof that the donor cells recolonize the irradiated bone marrow was provided in the following year by J. F. Loutit and his group in Harwell. Work from several centres was summarized at the conference by C. C. Congdon and T. Makinodan of Oak Ridge, J. F. Loutit, C. E. Ford and N. A. Mitchison of Britain, and by D. W. van Bekkum and O. Vos of Holland.

The discussion of the extremely intriguing immunological consequences (for example, the co-existence of two genetically different tissues in 'chimeras'; the nature of homograft reaction; the degree of cellular adaptation; the mechanism of actively acquired tolerance) was introduced by the papers of leading immunologists and biochemists dealing with fundamental aspects of immune reactions. The induction, rate of synthesis and degradation of antibodies were discussed by W. H. Taliaferro (Chicago); the nature of the antigen-antibody reaction was described by J. F. Dixon (Pittsburgh), S. J. Singer (Yale University), R. W. Wissler and his collaborators (Chicago), and the diversity of antibodies was analysed by D. W. Talmadge (Chicago). The relationship between immunological specificity and chemical structure was the subject of E. A. Kabat's (New York) presentation. R. S. Schweet and R. D. Owen (Pasadena) discussed the nature of the change which may occur in cells responsible for antibody formation, and presented a challenging scheme postulating that the foreign antigen impinges on the nuclear deoxyribonucleic acid of the host and that the process may be considered to be similar to that of bacterial transformation; while G. D. Novelli and J. A. DeMoss (Oak Ridge) considered current concepts of protein synthesis. The symposium brought together much basic information which may enable us to apply the new method in the therapy of human leukæmias, and showed that the time has arrived for discussing the mechanisms which may be responsible for cellular variation. This formed the subject of the eleventh symposium which was held in April of this year with the title "Genetic Approaches to Cellular Variation" (see *Nature*, 181, 1706; 1958).

Of the many research centres devoted to radiation, the Biology Division of the Oak Ridge National Laboratory has for long been in the forefront not least because it realized the need to integrate this polyglot subject with the advancing fronts of biological research. Last year's symposium is further evidence to show the far-reaching influence of these conferences and the foresight of their organizer, Dr. A. Hollaender.

P. C. KOLLER
P. ALEXANDER

PHYSICAL CHEMISTRY AT HIGH PRESSURES

Physico-Chemical Effects of Pressure

By Dr. S. D. Hamann. Pp. ix+246. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 42*s.*; 8.50 dollars.

THERE are several books concerned either with high-pressure technology or with the physics of high pressure, but this is the first to bridge the gap between these two subjects. Dr. S. D. Hamann, of the Commonwealth Scientific and Industrial Research Organization, Australia, has performed a valuable service in providing a concise summary of the effects of pressure in the field of physical chemistry. Although the book will be mainly of interest to physicists and chemists engaged in high-pressure research, it will also provide chemical engineers with a theoretical background to the subject.

The first part, dealing with the techniques of experimenting at high pressures, is concerned with the principles of small-scale experimental apparatus and, in particular, with those techniques, such as the generation of high transient pressures by shock waves, which have been developed during the past decade. The omission of the detailed information that is so essential in the design of high-pressure apparatus is offset by the provision of numerous references to original publications. The discussion of the effects of pressure on compressibility, phase changes, transport properties, electrolytic conduction and dielectric and optical effects deals in the main with changes brought about by pressures greater than one hundred atmospheres. In spite of this restriction, there are omissions, and some of the sections are of necessity very brief; neverthless, the treatment, which is largely theoretical, is well illustrated by carefully chosen data. The author is well known for his work on the equilibria and kinetics of chemical reactions under pressure, and the last part of the book, which contains authoritative chapters on these topics, will be of great interest to chemists. Two appendixes are provided; one containing a bibliography of Bridgman's measurements of the compressions of liquids and the other information about the effect of pressure on the freezing temperature of liquids.

Throughout the book an admirable balance between theory and experiment is maintained. Except in the section dealing with the strength of thick-walled cylinders, empiricism has been largely avoided, and an attempt has been made to give molecular models of the underlying causes of the pressure effects. In the words of the author, it is likely that time will prove some of the models wrong, but in the meanwhile they will have a use if they merely stimulate further research.

K. E. BETT

VETERINARY HANDBOOK

The Merck Veterinary Manual

A Reference Handbook of Diagnosis and Therapy for the Veterinarian. Second printing. Pp. ix+1398. (Rahway, N. J.: Merck and Co., Inc., 1957.) 7.50 dollars.

THIS publication, produced by the Merck Pharmaceutical Company of the United States of America, is intended as a reference handbook of diagnosis and treatment for the use of veterinary surgeons. Among the stimuli to its preparation was the wide and enthusiastic reception given to a similar handbook prepared for the medical profession.

While encyclopædic tomes of this type (it comprises 1,350 closely packed pages) inevitably have many weaknesses, it must be stated at once that this is a serious and, in measure, very successful attempt to provide the veterinarian with concise, authoritative and readily available information on the diagnosis and treatment of diseases of domestic animals. Emphasis, of course, has been placed on those conditions occurring in North America.

Not the least of the problems arising in the preparation of a book such as this is the matter of classification. This is greater in veterinary medicine than in human medicine because of the number and variety of species the former deals with, and the diversity of the pathological conditions encountered in them. In this manual the classification is primarily under the respective body systems, and the various diseased conditions, whether they come under the heading of general pathology or contagious disease, of each species are included. Exceptions are poultry and the non-domestic animals, which have sections to themselves. It is confusing to find diseases of cattle, sheep and pigs, horses and dogs, dealt with under the same systematic headings. One would have preferred to see each of the important species dealt with separately and the contagious diseases separated from the general ones. Surgery does not receive more than a mention when appropriate; nevertheless, those who practise in the veterinary field know that the division between clinical medicine and surgery is a purely arbitrary one and not infrequently that which may be classified as medicine necessitates surgical interference. As is the custom with books of this type, one starts with the name of the disease and then reads all about it. This, of course, is the opposite from that which prevails in the field. One commences with the animal and is primarily concerned with the clinical signs it exhibits. This is followed by a detailed examination of the various systems of its body with the view of ascertaining the site and, even more important, the extent of the disease. Its name is the last point. The task of the veterinary surgeon differs from that of the doctor in that he is chiefly governed by the economics of agriculture and thus he must accurately assess what the animal's chances of recovery are; thus prognosis is often more important than treatment. These are things that can only be taught by skilled diagnosticians working at the veterinary equivalent of the bedside and by pathologists in the post-mortem room. No book can effectively replace them.

The Merck Company are to be complimented for producing what is, of its type, an excellent book and one which, despite the criticisms made, will be found most useful to veterinary surgeons. It should be stated that it is completely free from any suggestion of advertising material.

J. G. WRIGHT

The Twice-Born

A Study of a Community of High-Caste Hindus. By Dr. G. Morris Carstairs. Pp. 343. (London: The Hogarth Press, Ltd., 1957.) 30*s.* net.

THE title of this book suggests that it is a study of the Brahmins of India and of their relations with the other superior castes. But this is not so. It is the study of a single social unit, the village of Deoli, and it is formulated from a psychological point of view, and not as a factual description. The author begins by stating his belief that it is in "the legacy of realistic imaginative writing to which the long association with Britain gave rise" that projections of Indian life as it is may best be found. Imagination is not, perhaps, to be demanded of official publications, but it should not be forgotten, in India or elsewhere, that since the issue of the first District Gazetteers in the 1860's, the Indian Government strove to publish the facts on which its actions were based. This mass of record and comment has still much to teach the serious student.

Dr. Margaret Mead in her preface describes this book as "a study of the differences in character which characterize three different castes in a remote and only recently modernized community". But caste is a Portuguese, not an Indian, word, and remote is a doubtful qualification in a sub-continent the people of which are such inveterate travellers and where accurate information frequently beats the post and Press. India has been modernized many times. Roman trade did it in the first century A.D. and the Aryans, indeed, did it before that. India has never been out of the world. Deoli had no wireless, but a decade of broadcasting, two decades of travelling cinemas, and the existence of a flourishing colloquial Press for more than a century, forbid naïvety.

The introductory chapters are curiously discursive. A party of Bhils intrudes into Chapter 8, unfortunately only to display the author's lack of preparation. For Bhils abound in these parts and the literature is adequate. The bulk of the book consists of recorded conversations with three chief informants, some of their written statements, and psychological tests.

On p. 307 it is stated that, in the word association test, Puranmal Mehta gave a delayed response to "Vagina", "Anger", "Girl", "Fæces", "Penis", and "In-laws". So should I. Oh, Seligman! Oh, Haddon! Oh, Balfour! K. DE B. CODRINGTON

Araucanian Child Life and Its Cultural Background

By Sister M. Inez Hilger. (Smithsonian Miscellaneous Collections, Vol. 133, Whole Volume.) Pp. xx + 439 + 80 plates. (Washington, D.C.: Smithsonian Institution, 1957.) n.p.

THE Araucanians of Chile and Argentina have retained their language and a good deal of their original culture after more than 400 years of contact with Europeans; much has been written about them, but little of this literature has been specifically concerned with the children. Sister Inez Hilger had much previous experience of child studies among North American Indian tribes, so she was well prepared to undertake this extensive and sympathetic account. The book contains much information about the people in general, since this is necessary to an understanding of the children. Its scope is best described by a quotation from the first sentence of the preface, "The purpose of this study is to record the ethnography . . . of the Araucanians . . . particularly their customs, beliefs and traditions in relation to the development and training of the child", and a psychological approach is expressly disclaimed, though certain psychological aspects emerged and others are implicit.

The book is clearly written and well illustrated; it maintains the high standards of the Smithsonian Institution. G. H. S. BUSHNELL

Gas Dynamics

By Klaus Oswatitsch. English version by Prof. Gustav Kuerti. (Applied Mathematics and Mechanics, Vol. 1.) Pp. xv + 610. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1956.) 12 dollars.

FIRST published in German in 1952, and now translated with only minor amendments, this excellent book on compressible fluid dynamics stands little diminished in value by the continued rapid development of its subject. Its distinction rests in the high degree of success with which Dr. Oswatitsch has related methods of analysis to physical understanding.

The first part of the book deals with both steady and time-dependent 'one-dimensional' gas flows; a wide range of topics is covered, including, for example, problems of combustion and detonation. The method of characteristics is introduced for unsteady flow. A lucid exposition of the equations of motion for flow in three dimensions follows, with more emphasis than usual on their integral forms. Attention is then narrowed to steady adiabatic inviscid flow, and the fundamentals and analytical methods of high-speed aerodynamics are surveyed in a section which occupies about half the book. Basic similarities and differences between various types of flow, and parallels with unsteady flow, are carefully brought out. The last two chapters are rather too-abbreviated sketches of the influence of viscosity and experimental methods.

This can be highly recommended as an illuminating and authoritative account, perhaps most useful to the reader who already has some acquaintance with the subject. E. P. SUTTON

Common Medicinal Plants of Darjeeling and the Sikkim Himalayas

By Dr. K. Biswas. Pp. vi + 157 + 50 plates. (Alipore: West Bengal Government Press, 1956.) Rs. 7; 11*s.* 3*d.*

THIS book, which has the benediction and recommendation of Sir Ram Nath Chopra, well known for his scientific work on drugs, opens with a chapter on "Herbal Charms" and does not seem to recover from this mixture of sorcery, magic and folklore. After the startling success of the alkaloids of *Rauwolfia serpentina* in the treatment of high blood pressure, it would be unwise to dismiss miraculous claims for some plants as baseless, but what is one to make of the following extracts? "*Drymaria cordata*: used as a medicine for dog-bites, and is also very useful as a throat paint in hay-fever, hay-asthma, diphtheria and pneumonia". "*Rhus succedanea*: juice of the leaves is said to blister the skin, used in curing indigestion and vomiting in children." Bald-pates may take hope, for *Nardostachys* "has the property of increasing growth of hairs on the head". Those who sigh for their lost youth need not despair for "*Curculigo orchioides* . . . taken with honey and cow's milk prevents weakness due to old age and bring (*sic*) in young strength and spirit in old men and women producing freshness in face and body". The book abounds in misprints and the half-tone plates are miserable. The line drawings are reasonably presentable. N. L. BOR

E P C

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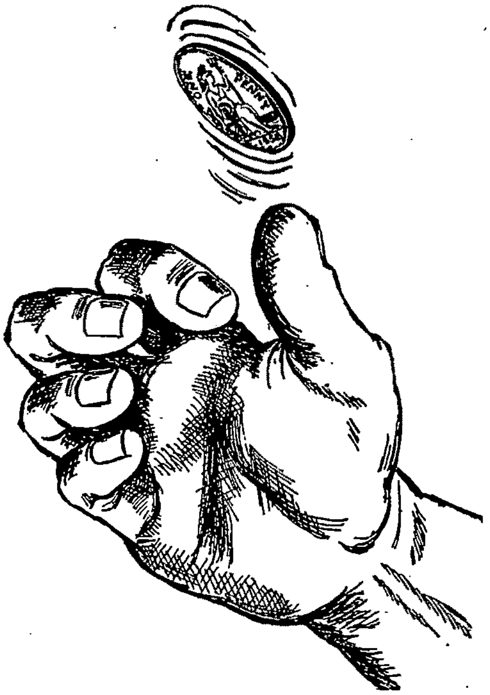

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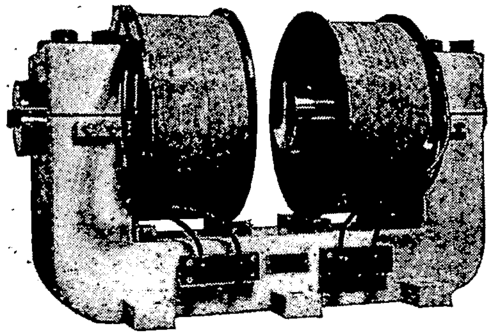

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VARIANCE CONTROL IN THE ANIMAL HOUSE

By Dr. J. D. BIGGERS, Dr. ANNE McLAREN and Dr. DONALD MICHIE
Royal Veterinary College, London, N.W.1

THIS article is concerned with the production of uniform laboratory animals, a subject which is of direct interest to any research worker using animals in his experiments, any organization using animals for the standardization of biological products, and also to any person concerned with the management of an animal house supplying several workers. Our interest in this problem stems from several years study on methods of controlling variation in mice, but the conclusions are applicable to work with other species.

Information in an Experiment

When we carry out an experiment we are usually interested in the value of some parameter, for example, the difference between two means, a regression coefficient or a relative potency in a biological assay. An estimate of the parameter is calculated from the observations and is subject to some uncertainty, the magnitude of which is measured by the variance of the estimate. This variance is proportional to the overall variance (the square of the standard deviation) of the responses or other biological properties being studied.

The information on a parameter is defined as the reciprocal of its variance. In practice, the amount of information that we require from an experiment is fixed by the limits of error of the estimate which we are prepared to tolerate. Thus, the more uniform we make a basic population the fewer individuals will we require to obtain the fixed amount of information. Methods of controlling the overall variance of populations are therefore of prime importance.

Causes of Variation

The variation of a group of animals, with respect to any measured character (for example, the response to a treatment), depends upon: (1) genetic factors, (2) environmental factors with persistent effects, and (3) environmental factors with transient effects. On the 'classical' model the total variance is considered as the arithmetical sum of the effects upon the animals of variation in these three categories. This view is now known to be an over-simplification. In each category we should further distinguish between those factors which increase the variance by varying from one animal to another, and those factors which act uniformly throughout the group but affect the degree to which the animals are influenced by other factors which do vary. Hitherto, attention has been focused on the varying factors. In this article we wish to direct attention chiefly to the role of uniform factors in controlling variability.

Genetic Factors

The more the individuals of a group differ in their genes, the more variable, other things being equal, will the group tend to be. The genetic differences between animals were for many years held to constitute the main cause of variation, provided that the animals were kept under uniform environmental conditions. The idea, therefore, developed that very uniform animals could be obtained by inbreeding, since in this way genetic differences between individuals can be minimized. This approach ignored the possible effects of uniform genetic factors upon variability: the genetic constitution of a population may influence the level of phenotypic variability even though all the members of the population have the same genetic constitution. In particular, it has been shown in recent years that a genetically uniform and homozygous population (an inbred strain) may be strikingly more variable than a population which is genetically equally uniform but heterozygous (the F_1 hybrid generation between two inbred strains).

The potential use of F_1 hybrids for biological assay was realized in 1946 by Mather[1], following his observation that F_1 hybrids between inbred strains of the Chinese primrose were more uniform than the parent strains. Unfortunately, this suggestion did not receive immediate attention from biological workers. In 1954, McLaren and Michie[2] and Biggers and Claringbold[3] (in ignorance of each other's and of Mather's work) reiterated this view as a result of investigations on the response of mice to 'Nembutal' narcosis and œstrogens, respectively. At that time few studies were available to indicate the generality of the phenomenon, but in the past three years a considerable literature has appeared. In 1954, Lerner[8] published his monograph, "Genetic Homeostasis", in which earlier work on the relative variability of homozygotes and heterozygotes is reviewed. The conclusion from this work was that for naturally cross-breeding species the heterozygous condition was likely to be more stable in face of environmental influences with persistent effects than the homozygous condition. In naturally inbreeding species we cannot necessarily expect the same to hold.

Table 1 provides a summary of the papers on naturally cross-breeding animal species which have appeared since Lerner's monograph. It can be seen that the relative uniformity of F_1 hybrids between inbred strains is a widespread phenomenon covering a large range of species and characters. There are two papers, however, which require comment. Grüneberg's findings[9] on a variety of anatomical characters in the mouse might suggest that only in a few cases are the F_1 hybrids more uniform than the inbreds. It must be stressed, however, that all but four characters are of the 'all-or-none' type, and that a variance calculated by the binomial theorem from the percentage incidence of such a character bears no direct relation to the variance of quantitative characters with which we are concerned. In the remaining four cases described by Grüneberg there is one instance where the F_1 is more uniform than the inbreds, two cases where the uniformity of the F_1 is about equal to that of the more uniform of the two parent strains, and one case where the inbreds are more uniform. The paper by Chai[10]

Table 1. COMPARISONS OF VARIABILITY BETWEEN INBRED STRAINS AND F_1 HYBRIDS BETWEEN THEM
The list only includes papers not found in the review by Lerner

Author	Species	Character	Result of comparison
McLaren and Michie (ref. 4)	Mouse	Duration of 'Nembutal' narcosis	Inbred more variable
McLaren and Michie (ref. 5)	Mouse	No. of lumbar vertebræ	Inbred more variable
Claringbold and Biggers (ref. 6)	Mouse	Response of the vagina to œstrogens	Inbred more variable
Yoon (ref. 7)	Mouse	Time of vaginal opening	Inbred more variable
Cuthbertson and Tomich (ref. 8) (quoted by Bacharach)	Mouse	Susceptibility to streptomycin sulphate	Inbred more variable
Grüneberg (ref. 9)	Mouse	Various morphological characters	See text
Chai (ref. 10)	Mouse	Response of seminal vesicle to testosterone	See text
Shultz (ref. 11)	Fowl	Egg shape, egg weight, shank length	Inbred more variable
Clough and Cock (ref. 12)	Fowl	Body weight	Inbred more variable
Mather (ref. 13)	*Drosophila*	Sternopleural bristle number	Inbred more variable
Thoday (ref. 14)	*Drosophila*	Sternopleural bristle number	Inbred more variable
*Maynard Smith and Maynard Smith (ref. 15)	*Drosophila*	Eclosion time	Homozygotes more variable
Reeve and Robertson (ref. 16)	*Drosophila*	Bristle number	No significant difference

* The comparison was between flies homozygous and heterozygous for a marked chromosome.

claims to show that there is no difference between the variability of F_1 hybrids and inbreds with respect to the response of the seminal vesicles to testosterone. In setting up his experiment, however, he applied the restriction that the mice should have body-weights between 9 and 12 gm. Since the weight of the seminal vesicle is likely to be highly correlated with body-weight, this restriction may have artificially brought the inbreds and F_1 hybrids being compared within the same range of variability.

The realization that F_1 hybrids were generally less variable than their inbred parents raises the question of the relative variability of inbred and random-bred animals. It seems quite possible that for some characters the greater genetic heterozygosity of random-bred animals might lead to their being phenotypically less variable than inbred animals, in spite of being genetically more variable. The use of inbred strains in biological assay and other quantitative work was stimulated in the early 1920's by King's pioneer work[17] on the growth of inbred and random-bred rats. Her observation that variability was reduced in the inbred population has unfortunately no clear-cut interpretation, since she practised selection for large body-size on the inbreds but not on the random-breds. Biggers and Claringbold[2] traced the history of this subject up to 1954 and concluded that there was no experimental proof that inbred strains were less variable than random-bred animals. The available literature is summarized in Table 2. The list is doubtless not comprehensive, but so far as we are aware it is not selected.

The results summarized in Table 2 make it clear that, unlike the comparison with F_1 hybrids, no general law can be asserted on the comparison of inbred strains with random-bred stocks. It is true that where inbred strains have been compared with unrelated random-bred stocks (Table 2, *B*), in only one instance were the inbreds less variable. But in the cases where the inbreds were compared with random-bred descendants of the same original population (Table 2, *A*) we find the inbreds to be in some instances more variable and in others less. This is not surprising, since we are dealing with the balance between two factors, both making for increased phenotypic variability—the genetic variability of the random-breds and the genetic homozygosity of the inbreds. We may expect the balance to shift from one strain or colony to another and from one character to another.

There is a practical conclusion for the experimental worker who does not wish to go to the considerable trouble and expense of maintaining inbred strains for the production of inter-strain F_1 hybrids. His most effective procedure will be to make an empirical choice from a number of random-bred colonies of that one which shows the least variability in the characters to be studied.

It is an attractive idea that one might be able to breed for uniformity, by selecting as the parents in each generation individuals falling within some restricted fraction of the total range of variation. The idea, unfortunately, receives no support from the available evidence. In fact, an *increase* of phenotypic variation has not uncommonly been encountered (see, for example, MacArthur[25], and Robertson and Reeve[26]). The possibility remains that selection from the middle fraction of the range might succeed where selection at one or other extreme fails. Falconer[27] has, however, tested this idea in *Drosophila*, and reports negative results.

It seems, then, that no purely genetical device for suppressing variability has yet been found to equal

Table 2. COMPARISONS OF VARIABILITY BETWEEN INBRED AND RANDOM-BRED ANIMALS

(*A*) Comparisons between inbred strains and the random-bred stocks from which they were derived

Author	Species	Character	Result of comparison
King (ref. 17)	Rat	Body weight	Random-bred more variable (but see text)
Morrell and Allmark (ref. 18)	Rat	Susceptibility to toxicity of neoarsphenamine	No significant difference
Rollins and Cole (ref. 19)	Rat	Response to gonadotrophins	Random-bred more variable
Kushner and Kameneva (ref. 20)	Fowl	Body size and hæmatological characters	Inbred more variable
Rasmuson (ref. 21)	*Drosophila*	Bristle number	Most inbred lines slightly less variable, some very much more variable
Reeve and Robertson (ref. 22)	*Drosophila*	Body size	Random-bred more variable

(*B*) Comparisons between inbred strains and unrelated random-bred stocks

Author	Species	Character	Result of comparison
Emmens (ref. 23)	Mouse	Vaginal cornification in response to œstrogens	Inbred more variable
McLaren and Michie (ref. 4)	Mouse	Duration of 'Nembutal' narcosis	Inbred more variable
Winton (ref. 24)	Rat	Susceptibility to toxicity of red squills	No significant difference (see Biggers and Claringbold, ref. 2)
Reeve and Robertson (ref. 22)	*Drosophila*	Body size	One inbred line more variable, one less variable

that suggested by the facts presented earlier: namely, the 'screening' of the F_1 hybrids of a number of strain combinations, or even the screening of random-bred closed colonies, in order to find a combination, or colony, with a low variance with respect to the character or response which is to be studied. A screening programme of this sort could, with advantage, be undertaken for the benefit of biological workers in general by some central organization, and we are informed by the Director that the Laboratory Animals Centre of the Medical Research Council has a project of this nature in hand, using mice. It should, however, be emphasized in the light of the next section on environmental effects that no comparison between different kinds or populations of mice can have any general validity unless the groups compared are raised under identical conditions of husbandry.

Environmental Factors

The properties of an environment, for example, temperature, humidity, composition of the diet, may vary from animal to animal during the formative period of their lives and in so doing will, of course, lead to the production of correspondingly variable animals. It is for this reason that so much effort has been expended in order to standardize conditions of, for example, temperature and diet in the breeding of laboratory animals. But again, the effect of uniform environmental factors upon variability has been virtually ignored in the past, although it has been briefly discussed by Michie[28] and by McLaren and Michie[4].

There are several reports in the literature which suggest that sub-optimal conditions may cause increased variability, even if they are uniformly sub-optimal from animal to animal. By 'sub-optimal' we mean simply conditions which deviate from those in which the given species or strain is known to be most vigorous, prolific and healthy. Increased phenotypic variability has been shown to result from both abnormally high and abnormally low temperatures in peas[29], high temperatures in *Drosophila*[14], malnutrition and reduced illumination in poultry[30] and inadequate diets in mice[31]. The work of Thoday[14] with *Drosophila* is particularly interesting since he showed that a raised temperature increased the variance of the sternopleural bristle number in both inbred strains and F_1 hybrids between them, the increase in variance being greater in the inbreds.

We have recently taken part in an experiment specifically to analyse the effect of uniform extreme climatic environments on the variability of growing mice as judged by their body-weights[32]. Table 3 shows that both the hot and the cold environments greatly increased the overall variance of the animals in both sexes. A large part of the effect was due to an increased variation among the mean values of the different litters, but a significant fraction was contributed by an increased variability among litter-mates.

Table 3. 10^5 × THE OVERALL VARIANCES OF LOG BODY-WEIGHT IN THREE DIFFERENT ENVIRONMENTS (from Ashoub *et al.*, ref. 32) Reproduced by permission of the Royal Society

Week	Females		
	Hot	Temperate	Cold
1	722	391	1,224
2	1,044	317	1,894
3	874	402	2,501
4	690	363	3,006
Week	Males		
	Hot	Temperate	Cold
1	763	458	1,093
2	801	344	1,361
3	641	518	1,629
4	575	502	1,799

The conclusion which we draw from this and the other findings summarized in this section is that the control of variability is not sufficiently ensured by establishing conditions in the animal house which act uniformly throughout the colony. These conditions must also be, so far as possible, optimal for the species or strain concerned.

Persistent Effects upon Variability: 'Constitution'

The variation which is determined genetically, together with that which is due to environmental conditions which have left a permanent imprint on the phenotype, may be termed the 'constitutional' component of the total variation. Its measurement may be used for classifying a group of animals into sub-groups which are more uniform than the original entire group as shown by subsequent tests. Biggers, Claringbold and Emmens[33] demonstrated this fact by classifying ovariectomized mice into sub-groups based on the response of the vagina to œstrone applied directly to the epithelium. The relative uniformity of the sub-groups persisted for ten weeks, at which time the experiment was discontinued. When, however, œstrone was administered systemically to the same animals by subcutaneous injection, the variability of the sub-groups was found to be as large as that of the original population. A reverse experiment showed that sub-groups more uniform than the original group could likewise be produced by tests using the subcutaneous route, but that the variability was as great as that of the original group when tested by the local intravaginal application of the hormone. Thus quite different factors of a constitutional nature may dominate the magnitude of the response according to the method of applying the stimulus.

Environmental Factors with Transient Effects

In contrast to the 'constitutional' component of variation there is finally a component due to environmental factors with transient effects. For example, two colonies of mice were used by Biggers[34] for the assay of locally applied œstrone at approximately 2-week intervals over 42 and 50 weeks, respectively. The slope of the dose-response line (in a quantal assay the slope is an inverse measure of the variance) showed considerable fluctuations in both colonies. These fluctuations must be attributed to unidentified transient environmental causes, which may or may not have been of the type which vary from one animal to the next. The next example shows that, as with genetic factors and environmental factors with persistent effects, a transient environmental factor may profoundly modify the variance of response even if it is applied uniformly throughout the group of animals. Biggers and Claringbold[35] found that the effect of injecting thyroxine was nearly to treble the variance of the response to œstrone. This effect did not persist on ceasing the injection of thyroxine. The administration of methyl-4-thiouracil approximately halved the variance of the response to œstrone, thus acting as a kind of 'uniformity drug'. In the latter case the reversibility of the effect was not tested. Earlier, Langham and Gustavson[36] had shown a similar effect in rats.

A comprehensive review of the role in variance control of uniform factors with transient effects has recently been published by Chance[37], who brings forward many new examples from his own observations. The environmental treatments implicated as having large effects on the variance of the response to a wide range of drugs in several species included temperature, the changing of cages, the size of the cage, the number of animals (female rats) in the cage (two per cage gave the least variance), and an unidentified attribute of the time of day which was found by Wilson[38] to cause changes over a thirty-fold range in the variance of the amount of histamine excreted by guinea pigs.

General Conclusions

The classical view of the causes of biological variation, whether genetic or environmental, is that these causes operate solely in so far as they vary from one member of the population of organisms to the next. We draw the inference from the material which we have reviewed that for the effective control of variation this view must be discarded. When the research worker has taken reasonable measures to ensure that a group of animals enjoy uniform circumstances of genetic background, environmental temperature, humidity and ventilation, diet, bedding, crowding, noise, routine disturbance and handling, etc., he has taken only the first step. He must next inquire whether the particular choice which he has made of genetic background, temperature, humidity, ventilation, diet, etc., is in fact the best for the given species in reducing the variance of the particular characters which he proposes to measure. It is useless to ensure a uniform level of some genetic or environmental factor if the level chosen is such as will in itself inflate the variance of the responses of the animals. There are one or two general principles which can aid his choice, as we have indicated. In general, the conditions which minimize variability seem to be those which promote the general vigour of the colony, whether we are speaking of genetic conditions (for example, heterozygosity) or environmental (for example, temperate as opposed to extreme climatic conditions). But in the end there is no substitute for trial and error. We would add a plea that workers should, if possible, publish their trials and their errors and thus put their experience at the disposal of others faced with similar problems.

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THE ROYAL INSTITUTION AND THE TEACHING OF SCIENCE IN THE NINETEENTH CENTURY[*]

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THE part played by the Royal Institution in encouraging the teaching of science during the nineteenth century was extensive and of considerable interest.

During the course of his work as clerk of the works there in 1799, Thomas Webster had occasion to supervise the work of men employed in the building and he noticed their frequent inability to do what was required of them. "I proposed then to found a school for mechanics in the house of the Royal Institution in which they should be taught such principles of Science as would be useful in their several occupations".

After pointing out that mechanical inventions had not progressed because of the lack of scientific knowledge among working mechanics, Webster gives an outline of his scheme. There would be a preliminary and compulsory course in plane geometry, for which Rossingnol's "Elements of Geometry" was suggested as a text-book; this was to be followed by the principles of projection, for drawing and understanding plans. The students would then proceed to the principles of mechanics and hydrostatics, for which it would be necessary to procure "a little apparatus for making the most useful experiments". At this stage the men were to branch off according to their several professions: the builders to study architecture and those concerned with machinery and with engines to study higher mathematics, natural philosophy and 'chymistry'. The climax to this most strenuous course was to be a competition open to all for "a certain number to be permitted to attend the Institution gratis". In Webster's eyes, "This would be a powerful incentive to exertion and it would be an honourable testimony in their favour and could scarcely prove of any inconvenience to the Institution".

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[*] Based on discourse delivered at the Royal Institution on May 14. A fuller version will appear in the *Proceedings of the Royal Institution*.

The scheme would start with a limited number of mechanics being sent by the proprietors of the Institution, and first attention was to be given to the instruction of bricklayers, joiners, tinners, iron-plate workers, "as these were the trades most connected with our improvements at this time". The scheme was accepted by Count Rumford, who was delighted with it, and by the Managers, after Webster had overcome the hesitations of Sir Joseph Banks: "by explaining to him how much the arts would gain by intelligent observation, I overcame a few political scruples which he had".

Some workmen were sent along and the project was launched. It is obvious, however, that from the beginning there was considerable opposition to the whole idea. Later, in 1837, Webster wrote, "I was not unacquainted with the political feelings of this time: but I did not think 'a little learning was a dangerous thing' if *judiciously bestowed,* although without due caution it might be capable of doing more harm than good. My idea was to make *good mechanics*—not to force them, like hotbed plants, out of the sphere in which they were so useful". Indeed, he pointed out the advantage of having the school in the house of the Institution, where the men "would be under the eye of the higher classes, and anything wrong would easily be put a stop to". He tried to disarm criticism by building a separate stone staircase for use by the mechanics, by constructing a gallery in the lecture theatre for those "who for obvious reasons would not like to sit down by their employers", and in other ways. All to no purpose. "But this project for improving mechanics, well intended as it was, which promised to be so useful, and which had already gained for the Institution 'golden opinions' was doomed to be crushed by the timidity (for I shall forbear to speak more harshly) of a few. I was asked rudely (by an individual I shall not name) what I meant by instructing the *lower classes* in science. I was told likewise it was resolved upon, that the plan must be dropped *as quietly as possible.* It was thought to have a dangerous political tendency. I was told that if I persisted I would become a *marked man*". By 1802 Webster had been granted leave of absence by the Managers "for the benefit of his health" and the whole project was abandoned.

Was Webster right in saying that the opposition was political? It could be. Certainly, other mechanics' institutes in different parts of England experienced similar difficulties during their early years. Other reasons have, however, been advanced. It has been said that the reason was largely financial. Alternatively, the point has been raised that the character of the Institution was to give 'fashion to science' rather than 'usefulness to science to poor and rich'.

Although the idea of a mechanics' school died almost at birth, nevertheless there was, in the early years of the Royal Institution, a certain amount of direct and continuous teaching. Both Davy and Faraday were given permission by the Managers to take private pupils in the laboratory, but the whole affair of private lectures was developed by W. T. Brande, who was appointed professor of chemistry and superintendent of the house in 1813. When appointed, he was teaching medical students at a chemical school, and permission was given to transfer these students to the Royal Institution. In 1826, a committee reported very favourably on these private classes. Brande, and later Faraday, gave these lectures in the laboratory at 8 o'clock in the morning and the lecturer received two-thirds of the subscriptions paid by the students. In its report to the Managers, the committee expressed its opinion that "these lectures have been productive of great advantage to the Royal Institution and have greatly raised its character as a school of Chemistry". The committee suggested that the lectures should be given in the theatre and that the laboratory be used for 'extended demonstrations' of the lectures. In this way more people could attend the lectures and more attention would be attracted by them. The lectures would still be given in the morning and so would not clash with the public lectures. The committee further suggested that lectures upon other subjects might be delivered upon similar terms by "Professors of eminence of different sciences" who might be invited "to give lectures to their own Pupils or classes, upon terms of admitting the Members to them gratis".

Brande was also concerned, a few years later, with an attempt to establish a school of practical chemistry at the Royal Institution. During November and December 1843, the Managers were considering a suggestion to start such a school, and Faraday and Brande had reported favourably on the scheme which would have involved special accommodation for some forty pupils. The scheme was finally turned down on the grounds of lack of space. The morning lectures continued, and among those attending were medical students from St. George's Hospital. There is evidence that some difficulty arose because the lectures were considered too technical and not sufficiently popular.

Thus, during the first half of the century many interesting attempts were made to use the facilities of the Institution for direct science teaching.

The Great Exhibition of 1851 gave a considerable impetus to scientific education and within a few years the Royal Institution had become the means of advocating the study of science. In his "Journal", for February 4, 1854, Tyndall writes: "Bence Jones is full of a project for getting seven great guns to lecture upon education". The project of the "seven great guns" soon materialized and seven lectures on science and education were delivered at the Royal Institution during 1854. Two of them are well known: William Whewell, "On the Influence of the History of Science upon Intellectual Education", and Michael Faraday's "Observations on Mental Education". A third lecture, "On the Importance of the Study of Chemistry as a Branch of Education for all Classes" by Daubeny, professor of chemistry and of botany in the University of Oxford, is interesting in several ways: first, in that it reflects the background of the time in its advocacy of scientific study based on faculty-psychology. "A study of this description . . . exercises a distinct set of faculties, just as a new gymnastic exercise calls into play a new set of muscles". Secondly, we have an interesting statement of the claim that a scientific education has advantages which a classical education has not. Here, Daubeny argues that it is desirable to train and develop at an early age "the faculty of minutely observing, of clearly apprehending and of correctly classifying the objects that present themselves". Further, after the student has left school or university he may not have an opportunity of gaining a sound knowledge of physical science, and, in any case, there are a considerable number of people who cannot stay the course in the present subjects. Finally, Daubeny expresses the desire that the universities should grant full facilities for the study of physical science.

Tyndall's own contribution to the series was "On the Importance of the Study of Physics as a Branch of Education for all Classes". He claims that the study of physics would be an advantage to all. For example, he asks, "Why should Members of Parliament be ignorant of the subjects concerning which they are called upon to legislate ? In this land of practical physics, why should they be unable to form an independent opinion upon a physical question ?" His own reactions to the lecture are interesting, and n a letter to a friend he writes : "The audience was a fine one, and included many men of eminence. Many Oxford men were present, and Faraday told me that they frowned and looked gruff at the commencement but that every man of them melted before the lecture was concluded".

This series of lectures is important in that they are evidence of an attempt to use the growing prestige of the Royal Institution to break down prejudice against science as a means of education, and to enable that subject to encroach upon the almost universal classical tradition. Some measure of their importance is seen from the discussion of them by Herbert Spencer in his famous work on education.

The story of the Royal Institution and the teaching of science during the latter half of the nineteenth century is mainly the story of the influence of individuals, and here the figure of John Tyndall overshadows all others. He had the advantage of two short periods of practical teaching at Queenwood College, where he taught physics and mathematics. In his teaching he laid stress on the practical side ; in science, he developed simple experiments for the boys to do, and in mathematics he taught practical applications of the mathematical principles. From this experience he undoubtedly learnt much that was of value to him later : the need to maintain interest when teaching and the art of devising simple but effective experiments. One of the more important contributions which he made later to the development of science teaching was the effective breaking down of prejudice by his attractive manner.

From his papers we may refer to several examples of his interest in educational questions. In 1866, Dean Farrer, then a master at Harrow, invited Tyndall to speak at the school. Tyndall's manuscripts contain the text of a speech to Harrow masters, delivered on November 15, 1866, in which his theme was the wonder and beauty of ordinary things and the need to introduce boys to the mystery enveloping the universe. "Those who imagine that science tends to destroy this mystery . . . are profoundly in error. It is science which reveals the insoluble nature of the mystery". He illustrates this by experiments dealing with the sensation of touch, with sound, light and crystallization. "All this was very wonderful to me when I first heard of it, and if properly expounded it would be very wonderful to you. No boy of intelligence and imagination could listen to such fairy tales unmoved".

Five years later he was elected a governor of Harrow School on the nomination of the Royal Society and he served in that capacity for twenty-one years, from 1871 until 1892. One can imagine his chief concern at the meetings of governors. In his "Journal", for May 21, 1884, he comments that the land for new buildings was going to cost £14,000 for foundations but that only £21 had been spent in the previous year on laboratories : "Science at Harrow is in a somewhat inanimate condition".

In another manuscript (dated June 4, 1865) entitled "Education and Physics", Tyndall tells us something of his views on the methods of teaching science. Elementary physics should be taught by experimental demonstrations. The facts of all its branches are not merely facts to be stored up in the memory but should also be copiously illustrated by experiments. Further, the relationships of such facts ought to be reasoned upon and connected, the pupils being encouraged to anticipate the connexions and then to check their anticipations by experiment. The questioning of pupils ought to go hand in hand with the performance of the experiments, and this method is preferable to that of formal lectures. The ideal way of teaching chemistry is by way of individual experiments performed by the pupils themselves. "This to my knowledge has been accomplished with great success in private schools". He recognizes, however, that the public schools may not be prepared to undertake the expense of erecting laboratories for this purpose, "though it is expected that the teacher should have a small laboratory for himself to enable him to prepare his demonstrations". He would confine attention to three sciences, elementary physics, chemistry and botany, which he prefers as "agents of discipline" to geology and physiology. Six hours a week should be devoted to science, of which three should be given to physics.

In 1859 the Department of Science and Art tried to secure better teachers of science by starting to award certificates as the result of examination. Tyndall acted as examiner for this as well as for the War Office. In an examination report, dated May 1866, he urges upon candidates and those who prepare them that "a little accurate knowledge is better than a general rambling and indistinct acquaintance with a subject". He returns to his favourite theme : "There is one great fault to be found with some . . . this is a belief that a knowledge of science means the recollection of certain phrases they have read. All teachers of science should remember that the great end of their teaching is to make their pupils *thoughtful*, prompting this thoughtfulness by making them interested and thoroughly conversant with every little step up which they are necessarily taken. The worst teachers are those who give their pupils to commit to memory or repeat to them so many dozen pages of a textbook ; the necessary result is a dislike to science".

In his written evidence submitted to the Devonshire Commission, he has several shrewd things to say as a result of his experience as an examiner. In his opinion, a great amount of sound, scientific knowledge had been diffused throughout Britain as a result of the South Kensington Examinations, although teaching appeared to be defective in practical experimentation. The amount of 'cram' was greater than it ought to be and many candidates ought not to have taken the examination. "Their incapacity must have been known to their teachers, provided the teachers themselves be not utterly incapable".

The Education Act of 1870 inaugurated the setting up of School Boards, and in his papers Tyndall has left a speech which he made just prior to the first elections to these Boards. He deals with some of the problems which are to be faced. Among these he notes, first, the problem of choosing teachers of the right quality. "The mischief done by incompetent teachers is beyond calculation". The next problem is that of text-books. "Almost every whipster imagines he can write a school book, whereas it requires the rarest faculty to write such a book." Here it may be noted that two of his own books, "On Heat" and "On Sound", were used in several public schools. He goes on to say, "The question of books will be one of the most important which the School Boards have to consider". Furthermore, the Boards will also have to determine the subjects to be taught. To the "three R's" he would add an elementary knowledge of some portion of physical science, in which he would include: the elementary facts and principles of chemistry; the nature of air and water and their functions in the human system; the facts and principles of combustion; the elementary facts of light, sound, heat, electricity and magnetism. "With the proper class-books the teacher would have no difficulty in making these things a source of unflagging interest to his boys."

In attempting to summarize the part played by the Royal Institution in the teaching of science during the nineteenth century, one may point out three stages by which the Institution's influence has developed. For nearly the whole of the first half of the century the emphasis, as we have seen, was on attempts at direct teaching. From one point of view, it may be considered that these attempts failed, and yet we may claim that not sufficient attention has been paid to them and that in many ways the Royal Institution pioneered interesting and important experiments of lasting value. The middle of the century saw the attempts to break down prejudice against science as a means of education and to enable it to encroach upon the almost universal classical tradition. Here again it is not unreasonable to say that the Royal Institution played an important part. Finally, it is hoped that sufficient has been mentioned of the influence of John Tyndall to show that, when Webster at the beginning of the century said that "the establishment of the Royal Institution ought to be considered as the commencement of a new era in the history of science in this country", he was a prophet indeed.

CONDUCTION MEASUREMENTS AT LOW TEMPERATURES

A ONE-DAY symposium on measurements of conduction at low temperatures was held by the Low Temperature Group of the Physical Society on April 11 at the Institute of Physics, and was attended by about fifty people. The committee of the Low Temperature Group, under the chairmanship of Dr. P. H. Sykes, arranged the symposium in a form similar to that of previous one-day discussions on the subjects of liquid helium and of low-temperature distillation, since it was felt that meetings of this nature make a valuable contribution towards the discussion and dissemination of recent ideas and results. Such symposia afford an opportunity, especially to younger research workers, of discussing their work informally and in much greater detail than would be possible in the more crowded and formal programme of a large-scale conference. While the time for each paper was restricted to fifteen minutes, almost as much time was allowed for discussion, so that in the course of the day it was possible to consider some thirteen contributions on several aspects of conduction measurements at low temperatures. In view of the informality of the symposium, no detailed record of the proceedings will be published.

The morning session, under the chairmanship of Dr. K. Mendelssohn (Clarendon Laboratory, Oxford), opened with a group of three papers on electrical and thermal conduction in semi-conductors.

Measurements, over the temperature range 2° K.–300° K., of the electrical conductivity and Hall effect in *n*-type indium antimonide with electron concentrations ranging from 2×10^{18} per cm.^{3} down to 5×10^{13} per cm.^{3}, were described by Dr. E. H. Putley (Royal Radar Establishment, Malvern). The ultimate purpose of the work was to estimate the purity of the parent material from the amount of electron scattering by ionized impurities at low temperatures. Because of the very small effective electron mass in indium antimonide, the electron mobilities are very high, rising to maxima as great as 700,000 cm.^{2}/V. sec. below 77° K., and the electron gas becomes degenerate at much lower concentrations than in other semi conductors so that, for example, the average relaxation times of electrons have to be obtained by integrating exactly over all energies, instead of assuming the usual formulæ for the cases of Fermi-Dirac statistics at high electron densities and of classical statistics. A theoretical calculation of the relaxation time, assuming additive inverse mean free paths for acoustical and impurity scattering, fitted the data at all temperatures, except those for impurity concentrations less than 10^{15} per cm.^{3} at temperatures below 50° K., for which the calculated conductivity exceeded the observed value by a factor of two or three. It is not yet possible to say whether this indicates a defect in the theory of impurity scattering or the presence of some additional scattering. It was pointed out by Dr. Ziman that the conventional use of the Born approximation in the theory of impurity scattering is incorrect; however, a more rigorous phase-shift calculation increases the discrepancy between the observed and calculated conductivities.

Dr. J. A. Carruthers (Clarendon Laboratory, Oxford) described measurements he had made with Dr. J. F. Cochran of the thermal conductivity of a series of *n*-type single crystals of germanium, to which Group 3 impurities had been added in concentrations ranging from 10^{14} per cm.^{3} to 10^{19} per cm.^{3}. The work was carried out between 4·2° K. and 0·2° K. as an extension to lower temperatures of previous results obtained above 2° K. In all the specimens heat was conducted by the lattice, and although in one of the pure *n*-type specimens with 10^{13} impurities per cm.^{3} phonons were scattered by the boundaries with 15 per cent specular reflexion, in all the other specimens phonons were scattered by boundaries and by an additional scattering mechanism. The phonon mean free path for this additional mechanism varied with temperature as $T^{0\cdot 8}$ in an impurity-band specimen, and varied as $T^{-1\cdot 5}$ in highly degenerate specimens, in rough agreement with a theory by Ziman on the scattering of phonons by a quasi-free-hole band with a low density of holes. For the purer specimens, the additional mean free path was approximately constant below 1° K. at values not correlated with the amount of doping impurities.

The aim of a theoretical contribution by Mr. I. C. Pyle and Dr. J. M. Ziman (Cavendish Laboratory, Cambridge) read by the former, on the scattering of phonons by a pair of impurity centres, was to explain the $T^{0\cdot 8}$ dependence on temperature of the phonon mean free path in impurity-band germanium, described in the preceding paper. Using a model proposed by Mott for lightly doped semi-conductors, which presupposes some degree of electrical compensation, the mean free path for scattering of phonons by second-order electron transitions between neighbouring pairs of impurity sites was shown to have the required decrease with temperature, and to reach a minimum value near 1° K., but the interaction was not sufficiently strong to explain the experimental results. First-order transitions, involving the complete absorption of a phonon, give a weaker interaction, but this would be increased by the fluctuations in the energies of the bound electronic states due to the random distribution of the impurities.

Electrical conductivity and galvanomagnetic effects in metals formed the subject of the last four contributions to the morning sessions.

Dr. R. W. Powell (National Physical Laboratory) described measurements, made in conjunction with Miss J. A. Nicholls and Mr. R. P. Tye, of the electrical and thermal conductivities to low temperatures of chromium, rhodium, iridium, platinum, rhenium, tungsten, cobalt, nickel, palladium, ruthenium, osmium, silver, and gold. Measurements on the specimens (which were all supplied by Johnson, Matthey and Co., Ltd., with the exception of the cobalt, which was prepared in the Metallurgy Division of the National Physical Laboratory) were also made to higher temperatures, and compared with results from the national laboratories in Canada and Australia. A study was made of the effects of heat treatment on the conducting properties of chromium in the form of a specially prepared electrodeposited tube, and it revealed the existence of an electrical resistance anomaly at about 40° C. after annealing, and of deviations from Matthiessen's rule.

In the first of the three papers on galvanomagnetic effects, Dr. R. T. Webber (U.S. Office of Naval Research) discussed measurements of the longitudinal and transverse electrical magneto-resistance of copper of extremely high purity, in fields up to 100,000 oersteds at 293°, 77°, and 4·2° K. At 4·2° K. the longitudinal magneto-resistance showed a clear-cut saturation, and all the results, except those on transverse magneto-resistance below 50,000 oersteds at 4·2° K., could be fitted to simple two-parameter analytical forms. Since the specimens were annealed polycrystalline wires of diameter greater than ten times the electron mean free path, no size effects were observed, yet the changes in resistance were smaller than those observed by previous workers on specimens in the form of strips of similar size. Kohler's rule was obeyed at 4·2° and 293° K., but not at 77° K. A similar breakdown of Kohler's rule in rhodium at 77° K., described by the next speaker, Dr. B. R. Coles (Imperial College of Science and Technology, London), is attributed to the presence at this temperature of comparable scattering by impurities and by lattice waves, each mechanism being assumed to have a relaxation time with a different lattice-symmetry and dependence on temperature, although, as pointed out by Dr. Ziman, this assumption, which is reasonable, has not been studied in detail. Rhodium also shows a reversal in sign of the Hall coefficient at high magnetic fields, as observed in other metals, and the Hall effect results can be fitted to a simple two-band model, provided one uses values of electron and hole densities which seem unrealistic in any other context. Recent work on the changes in the Hall coefficients of rhodium, palladium, and silver on alloying have shown that these are due, especially at liquid-hydrogen temperatures, not only to changes in the electronic structure, but also in part to alterations in the scattering mechanisms; and a careful interpretation of the results is necessary. In a short contribution on the theory of galvano-magnetism, Mr. F. García-Moliner (Cavendish Laboratory, Cambridge) stressed that, since the expression for the magneto-resistance contains a multiplier which involves the integration of a geometrical factor over the Fermi surface, even slight deviations of the Fermi surface from sphericity can produce large increases in the magneto-resistance. In lithium, the Fermi surface derived by Jones and Zener (with approximately 5 per cent anisotropy) gives the experimental order of magnitude for the magneto-resistance, while surfaces calculated more recently lead to results in disagreement with experiment by two orders of magnitude. The anisotropy also increases the Hall coefficients for the alkali metals by up to 3 per cent and for the noble metals by a rather larger factor sufficient to explain Dr. Coles's results on Hall coefficients.

The afternoon session, under the chairmanship of Dr. F. E. Hoare (University of Leeds), opened with three papers dealing with superconductors. Dr. L. Mackinnon (University of Leeds) reviewed previous ultrasonic conduction measurements in normal and superconducting metals, and described work in cooperation with Mr. A. Myers on absorption of ultrasound in tantalum and mercury. Different absorptions in superconducting and normal tantalum were observed, but the specimen used was not pure enough to show a large effect. Although in mercury, where a very pure specimen is easier to obtain, the effect is much more noticeable, the attenuation of longitudinal waves in the normal metal shows a peculiar behaviour on application of a transverse field. Further experiments on this effect are in progress; an earlier specimen has shown a good, if fortuitous, correlation with recent theories on the energy gap.

Measurements on the thermal conductivity of superconducting lead at temperatures close to 1° K., at which lattice conduction predominates, were described by Dr. H. Montgomery (Atomic Energy Research Establishment, Harwell). It was found that small percentages of alloying material cause only Rayleigh scattering of the phonons, but that plastic deformation greatly reduces the lattice conduction, and it appears that dislocations are distributed at random in annealed material, whereas in strained material they are assembled in mosaic walls. To overcome the effects of self-annealing at room temperature, measurements on lead alloys strained at 4° K. and on a harder metal, niobium, strained at room temperature, were made by Mr. P. M. Rowell (Clarendon Laboratory, Oxford). The thermal resistivity due to initially straining a niobium specimen varies as the 0·8th power of the strain, and as the niobium and lead alloy specimens are strained progressively, the extra thermal resistivity varies with temperature as $T^{-2\cdot 0}$, as expected from the work of Klemens and of van Bueren on dislocations. Pure lead specimens do not show a similar behaviour.

The last three papers dealt with various aspects of scattering by impurities.

The electrical resistance of molybdenum and tungsten specimens irradiated at 77° K. has been measured at helium temperatures by Mr. M. W. Thompson (Atomic Energy Research Establishment, Harwell). Increases in resistance are found to recover after thermal annealing, and activation energies have been determined for the principal recovery processes; these occur at − 170° C. and + 150° C. in molybdenum, and at − 80° C. and + 320° C. in tungsten. It was suggested that recovery in the lower temperature-ranges is due to interstitial atoms being released from traps, whereas that at higher temperatures is due to migration of vacancies. A resistance minimum observed in molybdenum near 10° K. became less pronounced after irradiation and recovered its original form only after annealing at 1,500° C. Miss J. N. Lomer (Clarendon Laboratory, Oxford) described work carried out with Dr. H. M. Rosenberg on a method for determining dislocation densities in α-brass by measurements of lattice thermal conductivity at liquid-helium temperatures. It was found that the dislocation densities introduced by strain are independent of the percentage of zinc alloyed, but depend only on whether the deformation is by single or multiple slip. The dislocation densities reach saturation at strains corresponding to the flattening-out of the stress-strain curves, and these saturation values increase with increasing zinc content. The method is useful for fatigued materials, where the dislocation densities for cyclic stress are found to be the same as for the equivalent tensile stress.

Experiments to determine the thermal resistance due to isotopes in crystals of isotopically enriched lithium fluoride were described by Dr. R. Berman (Clarendon Laboratory, Oxford). The scattering of single phonons can be calculated with reasonable certainty, but it is difficult to deduce the resultant thermal resistance, because the amount of mutual phonon interaction is uncertain. For low concentrations of either lithium-6 or lithium-7 the resistance is two to three times less than for the limit of very strong mutual phonon interactions; it is hoped to measure crystals with high concentrations of isotopes to determine the thermal resistance when mutual interactions are relatively weak. J. A. Carruthers

NEWS and VIEWS

National Physical Laboratory : Dr. J. A. Pople

Dr. John Anthony Pople has been appointed superintendent of the newly created Basic Physics Division at the National Physical Laboratory. Dr. Pople, who was born in 1925, graduated from Trinity College, Cambridge, being a 'wrangler' in the Mathematical Tripos. After a short period with the Bristol Aeroplane Co., he returned to Cambridge as a research student under the late Sir John Lennard-Jones. His work in this field led to the award of a Smith Prize in 1950 and election to a fellowship at Trinity College in 1951. Since 1954 he has been a lecturer in mathematics at Cambridge. This year he has been awarded the Marlow Medal of the Faraday Society. Dr. Pople has made theoretical contributions to a number of branches of molecular physics. Working with Lennard-Jones, he took part in the general development of the molecular orbital description of the electronic structure of molecules and has since been concerned with its application to specific problems. In addition, he has worked on the statistical mechanical theory of thermodynamic, dielectric and transport properties of liquids and gases. More recently, he has spent some time in the laboratories of the National Research Council of Canada at Ottawa, working on the interpretation of nuclear magnetic resonance spectra. The present physics programme of the National Physical Laboratory has its origin in the Laboratory's responsibility for measurement of physical constants and has a strong classical flavour; measurement of high pressures, ultrasonics, thermal conductivity and strength of materials are typical items. New fields to which consideration is being given are nuclear magnetics resonance, high polymer physics, and other aspects of molecular physics, including biophysics.

Chemistry at Khartoum : Prof. J. Miller

Dr. Joseph Miller, who is at present reader in physical organic chemistry in the University of Western Australia, has been appointed to the chair of chemistry in the University of Khartoum. Prof. Miller is a graduate of University College, London, where he obtained first-class honours in chemistry in 1939. On the outbreak of war, he entered the armed services and obtained a commission in the Royal Engineers. He served throughout the War in chemical warfare units and in various theatres in the Mediterranean, and was discharged in 1946 with the rank of captain. He returned to University College and completed his doctorate in 1948 with a thesis dealing with the hydrolysis of oxime esters. He then joined the staff of the University of Western Australia, where he built up an active research school in physical organic chemistry, the work of the group being directed mainly to the investigation of nucleophilic substitution in aromatic compounds. During 1954, he visited the United States as a Fulbright Visiting Lecturer and spent extensive periods at both the University of California and the University of South Carolina as well as visiting a number of other centres. Prof. Miller, who is married and has three children, proposes to take up his duties at Khartoum at the beginning of the academic year this month.

Brewing Industry Research Foundation : Dr. W. P. K. Findlay

Dr. W. P. K. Findlay has been appointed assistant director of the Brewing Industry Research Foundation, Nutfield, Surrey, in succession to Dr. A. H. Cook, who has recently been appointed director (see *Nature*, 181, 810 ; 1958). Dr. Findlay graduated in botany at the Imperial College of Science and Technology, London, and afterwards gained an Empire Cotton Growing Corporation Fellowship for research at Cambridge and at the Imperial College of Tropical Agriculture, Trinidad. In 1927, he was appointed mycologist at the Forest Products Research Laboratory of the Department of Scientific and Industrial Research, where he now holds the post of senior principal scientific officer. Dr. Findlay has been president of the British Mycological Society, chairman of the Biological Council and president of the Association of Applied Biologists.

Darwin–Wallace Centenary

The Royal Society, in conjunction with the Linnean and Geological Societies, is arranging a conversazione to be held on July 15 to mark the centenary of the reading before the Linnean Society of the paper "On the Tendency of Species to form Varieties", by Charles Darwin and Alfred Russel Wallace. A joint committee of the three Societies has chosen a number of exhibits, some of purely historical interest, others illustrating current research in fields in which Darwin and Wallace worked.

On the following day, July 16, the fifteenth International Zoological Congress opens in London under the presidency of Sir Gavin de Beer, director of the British Museum (Natural History). Sir Julian Huxley will deliver the Darwin–Wallace Memorial Lecture in the Royal Albert Hall during the inaugural meeting of the Congress of Zoology, at 11.30 a.m. on that day ; this Lecture will be open to the public, and seats (2*s.* 6*d.*) are available at the Box Office of the Royal Albert Hall. The record number of nearly two thousand members from fifty-eight countries are attending the Congress, the main theme of which will this year be evolution. All the papers have been printed beforehand so that they can be distributed at the sessions where they are read, and they will be issued, together with records of the discussions, as the Proceedings of the Congress.

Science in the Civil Service

In his chairman's address to the thirteenth annual delegate conference of the Institution of Professional Civil Servants at Hastings on May 19, Mr. E. Hewlett stressed the adverse effect on the structure of the whole of the professional scientific and technical Civil Service of the depression of status of higher grade professional and scientific staff which characterized the Service. Referring as example to the recent appointment of a Comptroller of the Patent Office from the administrative class without qualification in either science or law, Mr. Hewlett said that in 1925 a memorial was addressed to the Board of Trade which, after directing attention to the increasing importance of the Patent Office to our scientific industries, continued : "In modern industry, scientific invention exerts an overwhelming influence, inasmuch as only by invention can new industries be created and dying industries revived. We therefore . . . direct your attention to the desirability of ensuring that the Comptroller of the Patent Office, in addition to possessing the requisite legal knowledge, should, by education and training, be familiar with scientific discovery and development as applicable to manufacture". This statement, said Mr. Hewlett, has even more force to-day, but although the battle had seemed to be won in 1925 when the Institution's journal commented that the fundamental principle that professional, scientific or technical work should be controlled by properly qualified officers was gaining wider acceptance, it seems that the success once achieved might be snatched or whittled away in a few years time.

A motion before the Conference, submitted by the Patent Office Examining Staffs Branch, viewed "with the utmost alarm the continuing encroachment into posts requiring professional qualifications and experience of officers qualified only in an administrative capacity" and registered "its full support of all actions of the National Executive Committee to arrest this practice". The general secretary, Mr. Stanley Mayne, in a wide-ranging speech on May 19, cited numerous other instances of Government failure to deal effectively with scientific matters, and to provide the conditions which would attract to the Civil Service sufficient men and women of the highest scientific and technical qualifications. Public service, said Mr. Mayne, itself is bound to be much of its own reward, but the treatment of some groups was so discouraging as to be a national danger.

Agricultural Research

Replying to an inquiry in the House of Commons on June 16 regarding progress in research into the prevention of losses among lambs from Nematodirus, the Minister of Agriculture, Fisheries and Food, Mr. J. Hare, representing the Lord President of the Council, said that much research bearing directly and indirectly on Nematodirus was in progress all over the world. Fundamental research on the life-history and epidemiology of the parasite was proceeding at several agricultural research institutes in Britain and work on new anthelmintics was being carried out by the pharmaceutical industry. It was too early to assess the bearing of this work in reducing losses from Nematodirus, but Mr. Hare agreed this was an important disease among hill sheep and said he would see that the scale of research devoted to it was adequate.

On June 16, and again on June 19, Mr. Hare was questioned about the work of the Farm Buildings Research Committee. This Committee, set up by the Agricultural Research Council in June 1957, had met three times. A special unit had been established by the Research Council to survey existing buildings and the immediate requirements of farmers. Reports had also been called for from experts in animal physiology, pest infestation and agricultural machinery. In collecting this information the Council was co-operating closely with the Agricultural Land Service, but Mr. Hare said that it would be some time before the results of these inquiries enabled the Committee to formulate research requirements and recommendations to meet them. Two members of the Committee were members of the Royal Institute of British Architects and consultation with the Institute would be arranged when it was likely to be of value.

Aircraft Industry

Replying to questions in the House of Commons on June 16, the Minister of Supply, Mr. Aubrey

Jones, said that about 250,000 persons were employed in all branches of the aircraft industry and on present orders and inquiries it would be about 150,000 in five years time. He had recommended the industry to pursue a policy of diversification, so that problems arising from the contraction of orders for aircraft would be mitigated. His Department was not at present giving financial support to an Earth satellite programme but there were constant consultations with the Lord President of the Council and the Royal Society as to the scientific value of such a programme.

Committee on the Composition of Milk

THE committee on the Composition of Milk, set up in May by the Ministry of Agriculture, Fisheries and Food, held its first meeting on June 27, and decided to invite written evidence from any interested persons or associations. The committee's terms of reference, which include all aspects of milk composition at all stages of production and distribution, are as follows: "To consider the composition of milk sold off farms in the United Kingdom from the standpoint both of human nutrition and animal husbandry, and to recommend any legislative or other changes that may be desirable". The members of the committee are: Dr. J. W. Cook (chairman), Prof. R. G. Baskett, Mr. S. Clifford, Miss R. L. Cohen, Prof. E. L. Crossley, Dr. D. P. Cuthbertson, Dr. P. R. Evans, Mr. G. N. Gould, Prof. W. Holmes, Dr. H. E. Magee, Prof. B. S. Platt, Dr. A. Robertson, Dr. R. Waite, Mr. H. L. Webb and Dr. E. C. Wood. Evidence should be sent not later than October 31 to the Joint Secretaries, Ministry of Agriculture, Fisheries and Food, Great Westminster House (Room 280), Horseferry Road, London, S.W.1.

Causation of Cancer

AN introduction by Prof. A. Haddow, in which he pays tribute to Sir Ernest Kennaway's work, and twenty summaries of work in the different fields of cancer research have recently been published in "Causation of Cancer" (*The British Medical Bulletin*, 14, No. 2; May 1958. Edited by Prof. E. Boyland. Pp. 73–196+4 plates. London: British Council, 1958. 25*s*. net). Haddow summarizes the vast field of the mode of action of chemical carcinogens, and L. A. Elson discusses some dynamic aspects of chemical carcinogens. Cocarcinogenesis is dealt with by M. H. Salaman, and experiments indicating the irreversibility of the changes in the epidermal cell of the mouse after application of carcinogen are described by J. W. Orr, who, from a histologist's point of view, favours the concept of tumourigenesis as being the result of colonies of six or seven adjacent mutated cells. Avian carcinogenesis is reviewed by P. R. Peacock, who directs attention to McGowan's finding of weasel bites as a possible clue to the etiology of fowl tumours. Peacock's observation that cauterization 2–9 days after inoculation with virus will produce tumours anywhere in the fowl seems to offer possibilities of a quantitative estimation of viral antibody formation. F. Bielschowsky and E. S. Horning review the aspects of endocrine carcinogenesis, and H. N. Green describes his immunological theory of cancer. The present knowledge of possible exogenous factors in the causation of lung cancer is summarized by the late Sir Ernest Kennaway and A. J. Lindsay. There are papers by G. M. Bonser, D. B. Clayson and J. W. Jull on chemically induced bladder tumours, the biochemistry of bladder cancer by E. Boyland, on chemically induced liver tumours by J. M. Barnes and R. Schoental, radiation-induced skin tumours by Glücksmann, and radiation-induced tumours of the thyroid gland by I. Doniach. Occupational carcinogenesis is reviewed by M. W. Goldblatt, and A. L. Walpole and M. H. C. Williams describe the carcinogenic hazards encountered in the aromatic amine industry, and the work on the carcinogenicity of different fractions of mineral oil is reported by J. W. Cook, W. Carruthers and D. L. Woodhouse. I. Hieger presents data on the extremely important question of the carcinogenicity of cholesterol. Unfortunately, the table presented seems to indicate that the desiderata for biological examination of carcinogenic substances as described by E. Boyland earlier in the volume have not been fulfilled. W. M. Court-Brown summarizes work on the incidence of leukæmia and radiation, and R. H. Mole deals with the development of radiation leukæmias in animals and the dose-response relationship in radiation carcinogenesis. Many of the summaries contain data and points of view which have been published earlier and in some instances the limited space available has had a severely restricting effect upon the selection of relevant data.

Science Education in South Africa

THE Cape Section of the South African Association for the Advancement of Science has recently conducted experiments on methods for the popularizing of science for the general public and on improvement of science education in schools. First, its Subcommittee on Science Education suggested to the Department of Extra-Mural Studies in the University of Cape Town that it should hold a refresher course for science teachers as one of its vacation courses. In July 1957 courses covering the physical and biological sciences were attended by 160 science teachers and inspectors. Further courses will be held annually, and other South African universities in each of the four provinces are now following suit and holding similar refresher courses. Secondly, in collaboration with the Royal Society of South Africa and the Adult Education section of the Department of Education, Arts and Science, the Association organized a science exhibition in Cape Town in March of this year. Held in the historic eighteenth century Old Supreme Court, twenty-two exhibits on various aspects of scientific research in Cape Town were displayed by some departments of the University as well as the South African Museum, the Royal Observatory and numerous industrial and medical research institutions, and amateur scientists. The main purpose was to present to the general public current research problems in a simple manner, so as to offer the layman the opportunity of becoming more knowledgeable about science and the role of science in society. The newspapers gave full coverage in feature articles and editorials, indicating clearly that such knowledge has become almost a civic duty for an informed democracy in the present age; radio broadcasts were also given along similar lines. All local schools were invited to send senior pupils so as to arouse interest in the young in taking up science as a career. During the five-day period that the exhibition was open, 5,000 people of all ages and races attended. Simultaneously, a series of science films were shown by the Association. As an experiment it was highly successful, and the Association is now planning a similar exhibition on a national scale.

Reports on Radiation Chemistry

THE United Kingdom Atomic Energy Authority Research Group has recently published selected abstracts of unclassified reports in the field of radiation chemistry and a bibliography of the published literature up to February 1957, compiled by R. W. Clarke (pp. iv+209. A.E.R.E. *C/R* 1575. Parts 1–6. Supplement 1. London: H.M. Stationery Office, 1957. 28*s.* net). This publication contains 877 references and is divided into six sections, dealing with water and aqueous inorganic systems; organic compounds; gaseous systems; solid systems; biochemistry and radiobiology; and miscellaneous, including colloids, applications of radiation and general reviews. Author and subject indexes are provided. In the individual sections, report abstracts are given first, followed by annotated 'open literature' references. The report references are arranged alphabetically and serially by report reference number, and the other references by author. Recent declassified American reports are included.

Guide to Literature on Atomic Energy

A HANDY booklet entitled "Guide to U.K.A.E.A. Documents", edited by J. Roland Smith (pp. 20. London: United Kingdom Atomic Energy Authority, 1958), provides a general description of the form in which information concerning the U.K. Atomic Energy Authority is published with special reference to its own publications and of their availability to the public. After explaining that the Authority consists of three Groups—Industrial, Research and Weapons Groups—and a London Office and that scientific and technical information is issued by the Groups independently, the Guide details how unclassified information is published and where unclassified documents may be obtained or consulted. Current reports are listed every month in the "U.K.A.E.A. List of Publications Available to the Public" which the Authority's library at Harwell compiles and issues free of charge. Cumulative lists are also published. Classified documents cannot be made generally available, but in certain circumstances may be accessible to industry, research and government organizations. Finally, the Guide lists and explains the various serial codes and numbering systems used by the Authority for reference to documents and reports. This will be of great value to librarians and cataloguers. For material of more general interest, for example, news of the Authority's activities, lectures delivered by members of the staffs, lists of patents, etc., attention is directed to the monthly bulletin, *Atom*, which is issued by the Director of Public Relations from the London Office (11 Charles Street, S.W.1).

The African Pygmies

A PAPER entitled "The African Pygmies", by Prof. R. Ruggles Gates, has recently appeared in *Acta Geneticae, Medicae et Gemellologiae* (7, 159; 1958). A detailed discussion of the early literature is given with observations on skin colour, blood groups, and skull and skeletal measurements. It concludes with theories on the origin and relationships of the African Pygmy. The early literature shows that Pygmies occupied a much wider area than at present, which included the Cameroons, Sierra Leone and probably Liberia. Accounts are given of early as well as later European contacts with the tribes. The Pygmies are of ancient origin, with mahogany skin and hairy body. The Negroes have since acquired a black skin by mutation and their bodies have become hairless. The common ancestor of both is thought to be a tall mahogany-skinned race with a hairy body, but this race may now be extinct. The dwarfing of the Pygmy is the result of a single gene mutation of the achondroplastic type. Racial mixture with the Negroes is considered. The Pygmies hunt in the forest, supplying meat to their Negro overlords, who in turn give the Pygmies bananas, this being a symbiotic relationship. However, this is fairly recent, for prior to the introduction of the banana the Pygmies probably fed themselves. Forest Negroes frequently take a Pygmy wife and the children become 'Negroes', but the reverse does not occur; consequently, the Pygmies remain pure except for occasional unofficial mixing. The F_1 hybrids are intermediate in stature and backcross to the Negroes, so becoming absorbed. Measurements show that the Pygmy skull is frequently little smaller than that of the Negro. The ranges apparently overlap, although some Pygmy skulls are very small. The Pygmy skull is very primitive and characteristic, and the Pygmy teeth and jaws are the worst in the human race. This probably has a nutritional basis.

Institute of Physics

AT the annual general meeting of the Institute of Physics held in London on July 1, Sir George Thomson (master of Corpus Christi College, Cambridge) was elected president. Dr. R. W. Sillars was elected a vice-president; Dr. J. Taylor, honorary treasurer; and Prof. F. A. Vick, honorary secretary. The two new ordinary members of the Board elected were Dr. A. C. Menzies and Dr. J. Topping. Sir Lawrence Bragg (resident professor and director of the Davy Faraday Laboratory of the Royal Institution) was elected to honorary fellowship in recognition of his eminent work and valuable contributions to knowledge in the field of physics.

Royal Meteorological Society: Officers for 1958–59

THE following were recently elected to office in the Royal Meteorological Society: *President*, Prof. P. A. Sheppard; *Vice-Presidents*, Dr. A. W. Brewer, Dr. H. L. Penman, Dr. C. H. B. Priestley and Dr. R. C. Sutcliffe; *Vice-President for Canada*, Mr. R. C. Graham; *Vice-President for Scotland*, Mr. J. R. Atkinson; *Treasurer*, Mr. B. C. V. Oddie; *Secretaries*, Mr. P. J. Meade, Dr. R. S. Scorer, Mr. J. S. Sawyer (*Editor*), Dr. A. G. Forsdyke (*Librarian*).

All-India Congress of Zoology

THE Zoological Society of India is organizing the first All-India Congress of Zoology at Calcutta during October 31–November 6. It is the first time that an attempt has been made in India to hold such a conference and to bring together all the zoologists of the country. A number of delegates from foreign countries are expected to attend. The last date for submission of papers to be read before the Congress is August 15. Further information can be obtained from Dr. B. S. Chauhan, Zoological Society of India, 34 Chittaranjan Avenue, Calcutta 12.

The Royal Society and the Nuffield Foundation Commonwealth Bursaries

AWARDS under the Royal Society and Nuffield Foundation Commonwealth Bursaries Scheme have been announced as follows: Prof. G. M. Badger, professor of organic chemistry, University of Adelaide, to assist him to visit Cambridge during January–May 1959, in order to study recent advances in organic chemistry, with special reference to natural products; Prof. J. H. Blaney, professor of mathematics, University College of Ghana, to enable him, during September 1958–January 1959, to have discussions and work with mathematicians at Sydney and Singapore with interests in number theory close to his own; Dr. W. Cochran, lecturer in physics, University of Cambridge, to enable him to travel to Chalk River in order to acquire experience of neutron diffraction techniques, for about a year from August 1958; Mr. A. B. Cribb, lecturer in botany, University of Queensland, to enable him to examine type and other specimens of marine algae, particularly early collections of Australian algae, at the British Museum (Natural History), Kew and other British herbaria, for a year from January 1959; Dr. R. H. Estey, of the Department of Plant Pathology, Macdonald College, McGill University, to assist him to learn new and different techniques in plant pathology and mycology, at Nottingham for two months from July 1958; Prof. T. Gillman, professor of physiology, University of Natal, to enable him to study certain special problems of regeneration of skin, principally at University College, London, during January–July 1959; Dr. P. Gray, lecturer in physical chemistry, University of Leeds, to enable him to study free radical reactions by mass spectrometric and electron-spin resonance techniques at Vancouver, for nine months from September 1958; Prof. H. Kleerekoper, professor of zoology, McMaster University, to enable him to collect and study limnological data from Lake Moneague, Jamaica, in July and August 1958, in order to add to the knowledge of the relationships between biological productivity and the physical and chemical nature of the bottom sediments of a tropical lake; Prof. R. J. Rossiter, professor of biochemistry, University of Western Ontario, to enable him to continue research on the biogenesis of phospholipids, at Canberra for a year from December 1958; Dr. G. Salt, lecturer in zoology, University of Cambridge, to assist him to visit West Pakistan for about six months from October 1958 in order to extend his work on the reactions of insect hosts to ichneumoid parasites and to attempt to apply it to the control of insect pests of crops by means of parasites; Dr. D. A. Scogings, senior lecturer in land surveying, University of Natal, to enable him to travel to University College, London, in July 1958 in order to carry out research in photogrammetry for about six months; Dr. T. B. Teoh, lecturer in pathology, University of Hong Kong, to assist him to study bile thrombi as a means of throwing light on the problems of non-obstructive biliary cirrhosis, at University College Hospital Medical School, London, for a year from September 1958; Dr. C. E. Wright, senior scientific officer, Plant Breeding Station, Loughgall, Northern Ireland, to enable him to study work in New Zealand on blind seed disease of ryegrass for seven months from September 1958.

"Administration and Defence in a Technical Age"

Reference is made in the editorial article under this title in *Nature* of June 28 to the contribution by Mr. R. Blake to "Soldiers and Government". Mr. Blake has pointed out that, although he is in full agreement with what is said by Mr. M. Howard in his introductory essay, he himself is responsible only for the essay on Great Britain.

Announcements

The Rennie Memorial Medal for 1957 of the Royal Australian Chemical Institute has been awarded to Dr. J. H. Bradbury. The H. G. Smith Memorial Medal has been awarded to Dr. K. L. Sutherland for his research work on flotation and allied fields.

The Duke of Northumberland, who was appointed chairman of the Agricultural Research Council some time ago, has now taken office in succession to Lord Rothschild, who retired on June 30 after ten years service as chairman.

The British Association, after sixty-seven years in Burlington House, is moving into a suite of offices in the house belonging to the Royal Society of Arts. From July 14 the address of the Association will be: 18 Adam Street, Adelphi, London, W.C.2. Telephone Trafalgar 5733/4.

The Trustees of the Ciba Foundation, wishing to encourage well-conceived research relevant to basic problems of ageing, invite candidates to submit papers descriptive of work in the field for the fifth and final awards, which are to be made in 1959. Further information can be obtained from Dr. G. E. W. Wolstenholme, Director and Secretary to the Executive Council, Ciba Foundation, 41 Portland Place, London, W.1.

An International Congress on the Modern Educational Treatment of Deafness will be held in the University of Manchester during July 15–23. The Congress has been organized at the request of the Ministry of Education. Further information can be obtained from Jean N. Howarth, Department of Education of the Deaf, The University, Manchester 13.

An informal discussion of the Faraday Society on Free Radical Stabilization will be held in the Department of Chemistry of the University of Sheffield on September 4 and 5. Further particulars can be obtained from Dr. B. Stevens or Dr. H. T. J. Chilton, Department of Chemistry, University of Sheffield.

At the invitation of the Hellenic Society for the Protection of Nature, the Sixth General Assembly of the International Union for Conservation of Nature and Natural Resources will be held jointly with its Seventh Technical Meeting, in Athens, during September 11–19. Further information can be obtained from the International Union for Conservation of Nature and Natural Resources, 31 rue Vautier, Brussels.

The first International Congress in the Aeronautical Sciences, organized by the International Council of the Aeronautical Sciences, will be held in Madrid during September 8–13, when Dr. Theodore von Kármán will preside. The programme is being arranged by committees under the chairmanship of Prof. Maurice Rey, director of the Office National d'Etudes et de Recherches Aeronautiques, Paris; and by Col. A. Perez-Marin, technical secretary-general, Istituto Nacional de Technica Aeronautica, Madrid. British scientists or technologists wishing to attend should apply to Dr. A. M. Ballantyne, 4 Hamilton Place, London, W.1. The address of the Secretariat of the International Council of the Aeronautical Sciences is: Institute of Aeronautical Sciences, 2 East 64th Street, New York 21, N.Y.

THE FLOW OF BLOOD IN RELATION TO THE VESSEL WALL

A MEETING was held on June 13 to discuss the flow of blood in relation to the vessel wall, at the Charing Cross Hospital Medical School, London, by invitation of the Clinical Research Sub-Committee of the Hospital.

The chairman, Dr. N. C. Lake, welcomed nearly a hundred guests to what was probably the first meeting ever called specifically to discuss 'hæmorheology'. We sometimes regret the invention of still more names for the smaller branches of science; nevertheless, Dr. Lake pointed out, hæmorheology covers a very significant and important field of study, which is really wider than that of hæmodynamics. He briefly outlined a number of problems in surgery and medicine in which the nature of the flow of blood must play a crucial part. (An account of the medical aspects of the discussion will be published elsewhere.)

Dr. G. W. Scott Blair (University of Reading), a rheologist, then read a paper entitled "A Survey of Work on Flow of Blood through Tubes". He pointed out that blood is not far removed from a true (Newtonian) fluid in its behaviour when flowing through narrow tubes, but its deviations from such behaviour are very important. First, any non-spherical particles will tend to align themselves statistically in the direction of flow. Secondly, larger and heavier particles will tend towards the centre of the stream, leaving a layer devoid of particles near the walls. Thirdly, clumping of red cells not only causes them to displace white cells but also tends to increase the 'viscosity' (defined as the ratio shear stress/rate of shear) in the region of low stress, namely, in the centre, in such a way as to flatten the figure of extrusion. This resembles superficially the effects of turbulence; but, although turbulence of various kinds may occur, especially in large vessels, the two phenomena should not be confused. The importance of changes in the relative concentrations of the components of blood resulting from these radial distributions may be expected to be considerable.

Historically, these deviations from the Poiseuille–Hagen law have been studied by two independent and often disconnected groups of workers. The empirical facts concerning the flow of blood have been developed since the time of Poiseuille by a number of authors; in recent decades mainly in Sweden. The theoretical study of these anomalies has accompanied measurements in quite other systems, including paints, clays and plastics. Only recently have the two lines of work converged, to great mutual advantage.

Dr. A. L. Copley, who directs the Research Unit recently set up at Charing Cross Hospital for the study of hæmorheology, then read a paper giving the results of his experiments, *in vitro*, or more correctly, '*non-in-vivo*', since many of the glass surfaces of his viscometers were coated with fibrin, silicone, etc. He used two methods of experiment. In the first, the blood, serum or plasma is contained in a horizontal tube, the central portion of which is narrow, while the two ends are of the same diameter and much wider. The flow is timed over a selected distance in the wider tube, where viscous resistance and surface tension are negligible. The material can be sheared backwards and forwards at different pressures through capillaries of different radii and, if necessary, lengths, while deviations from the fourth-power radius and inverse length laws are measured. The viscometer was checked with a true fluid, sucrose solution, and was found to be satisfactory.

The second apparatus is a tilting-tube viscometer, in which an 'index' of liquid is timed as it slides down the tube at different angles of tilt. Extra pressure can also be applied if desired. Here a correction must be made for surface tension, unless the angles of contact at the two ends of the index are identical, which is seldom the case.

When indexes of blood or its components flow fairly fast down these tilted tubes, a layer is left behind, adhering to the wall, and the thickness of this layer can be calculated. At large angles the sines of which differ but little, samples flowing at the same speeds give adherent layers of a thickness which depends on the angle of tilt.

Preliminary but very encouraging experiments were also described showing significant differences in adherence and in flow-rates when the walls of the tube had been coated with fibrin, silicone, etc. Dr. Copley briefly outlined his theory of the part played by fibrin and fibrinogen in the endothelium.

Dr. P. H. Staple described his work with Dr. Copley on biomicroscopic observations *in vivo* of the plasmatic zone in the capillary beds of frogs and of Syrian and Chinese hamsters. His drawings showed clearly the presence of Poiseuille's 'marginal zone' and, by adding graphite particles and dyestuffs to the flowing material, the authors were able to confirm, for the first time, a number of observations on the effects of rates of flow of blood on the immobile portion of the marginal zone, postulated by Poiseuille more than a century ago.

Many points were raised in discussion on these three papers. Prof. K. Weissenberg stressed the complexity of rheological phenomena and spoke of the causes of different types of turbulence and of flow instability. Other speakers raised points concerning the nature of viscous anomalies in blood, and it was pointed out that it is not possible to infer the presence of adherent layers in full capillaries from the presence of layers which are left behind when an index flows down an inclined tube. Dr. Copley believes, however, from other evidence, that there must be some relationship between adherence of indexes and that in full capillaries.

Two visitors from abroad then addressed the meeting. Prof. M. H. Knisely, of the Department of Anatomy, Medical College of South Carolina, showed a beautiful colour film illustrating the movement of red and white cells in the living animal. Under pathological conditions, the red cells form a sludge which tends to collect along the bottom of the larger vessels. Deep sludges are, of course, well known in post-mortem conditions, but Prof. Knisely's film showed them in anæsthetized animals which were still alive. Observations had also been made on vessels in the eyes of very ill and even dying patients. It was claimed that, in perfect health, red cells show no agglutination whatever and, indeed, repel one another.

Dr. F. K. Beller, of the University of Tübingen, also read a short communication on micro-coagulation processes on the vessel wall, in which he said that the verification by Drs. Copley and Staple of Poiseuille's claims concerning the plasmatic zone threw much light on hitherto inexplicable results.

The chairman, in closing the meeting, said that it was clear from the vigour of the discussion that the subject had provoked much interest. It was hoped that similar meetings would be arranged in other places where work on the flow of blood is being undertaken.

G. W. Scott Blair

SEDIMENTATION AND OROGENY

THE Fifth International Congress of Sedimentology was held in Geneva and Lausanne during June 2–7, under the joint chairmanship of Prof. Augustin Lombard and Dr. Arnold Bersier, and was attended by more than 160 members from eighteen different countries. About forty-five papers were presented, covering diverse aspects of recent and ancient sedimentation. The central theme of the Congress, however, was the nature and origin of flysch and molasse, and excursions in the Pre-Alps and in the Mittelland were arranged for the study of these deposits in the field.

To many of the Swiss geologists flysch and molasse were clearly terms peculiar to the Alpine orogeny and, despite Marcel Bertrand's wider application of them as early as 1894, never designed for export. Even with this limited usage the gradual application to them of both a lithological and a stratigraphical significance has led to the establishment of such anomalies as "Flysch à faciès molasse" and "Molasse à faciès flysch". Since molasse has also been defined as a rock type (by Lucien Cayeux) the term may be used with a petrographical, facies or stratigraphical significance.

Nevertheless, it was evident that most members of the Congress employed the terms as descriptive of facies and sought criteria whereby the syn-orogenic and post-orogenic sediments of mountain chains other than the Alps might be recognized. Typical of the studies having this end in view were those from Russian contributors describing Upper Carboniferous 'flysch' and Permian 'molasse' from the Urals–Volga oil-bearing region. The most familiar development of the flysch is the regular alternation of shales with poorly sorted micaceous sandstones, often graded and convolute and carrying, at their bases, a variety of cast structures and trace-fossils. It was, of course, pointed out that any or all of these features may be lacking in considerable thicknesses of flysch successions and that none of them is necessarily confined exclusively to syn-orogenic sediments. Nevertheless, there was general agreement that, when present together, they provide an assemblage characteristic of such deposits. The relative proportions of sand and shale in the flysch were regarded as an indication of the distance of the zone of deposition from the rising mountain front.

Opinion differed widely regarding the depth of water in which the flysch was deposited. American communications dealing with modern marine sediments, especially those off the southern Californian coast, made it clear that basins at a depth of 1,000 metres or more are filling with sands interbedded with normal deep-water muds. These were compared with Pliocene basins in California, completely filled with a similar sequence of sediments, where the shales are believed to have served as source beds of petroleum for which the sandstones now provide the reservoirs. The association of Eocene flysch (on the Spanish side of the Pyrenees) with neritic sediments, as described in another communication, however, suggests that depth of water is not necessarily a critical factor. It was noteworthy that the majority of geologists working on modern marine sedimentation accepted turbidity currents as widespread agents of clastic deposition. While the general opinion clearly regarded them as playing an important part in the formation of flysch, doubts were expressed of the need to regard all flysch-type sediments as having originated in the same way.

The change from syn-orogenic to post-orogenic sedimentation must inevitably be gradual and a vertical transition from flysch-type to molasse-type sediments or an alternation of the two facies is likely to be the rule rather than the exception. Confusion arises only where the terms are used in a stratigraphic sense. Molasse, with its massive sequences of poorly sorted sandstones, often strongly current-bedded and associated locally with thick conglomerates (*Nagelfluh*), and with its evidence of intraformational erosion and of cyclical sedimentation, has a characteristic lithology, though in petrographical character its individual units may not differ markedly from those of flysch. Confusion is unfortunately caused by the use of 'macigno' as a petrographical term (following Omalius d'Halloy, Brongniart and Cayeux) for the micaceous sandstone with a mixture of calcareous and argillaceous cementing material which is a common lithology in the molasse. In the Macigno formation of the Apennines the same rock type with beautiful grading, convolutions and sole-markings occurs interbedded with shales in a succession regarded by the Italians as typical flysch.

In the molasse, even more than in the flysch, there is a pronounced zonal distribution of lithologies, with conglomerates bordering the new mountain chains and fine sandstones and shales, often with evaporites, on the external margin of the fore-trough. A number of communications dealing with the petrographical and lithological features of the molasse emphasized the variation to be anticipated between one paralic basin and another and the difficulties to be faced in attempting to reconstruct the history of the final stages of an orogeny from purely sedimentary evidence.

The papers presented at the Congress are to be published as a special number of *Ecologae geologicae Helvetiae*. At the meeting of the International Association of Sedimentology, held during the final session of the Congress, Dr. F. P. Shepard, of the Scripps Institution of Oceanography, was elected president in succession to Prof. C. W. Correns.

J. H. Taylor

ASSOCIATION FOR RADIATION RESEARCH

SOME 170 persons attended the seventh meeting of the Radiation Research Visiting Club held at the Medical Research Council Experimental Radiopathology Research Unit, Hammersmith Hospital, on May 9 and 10. About 100 were present at the open business meeting at which the need for a rather more formal organization was debated under the chairmanship of Prof. F. S. Dainton. This meeting brought to an end the first phase in the existence of the Club, which hitherto has had no rules, no committee, and no subscription, its only existence between meetings having been a list of 'member centres' with some names of individual radiation research workers. The whole responsibility for each meeting has rested on the hosts who have come forward with invitations, and they have been at liberty to arrange the meetings entirely as they wished. The informality of the meetings and the absence of organization appealed to most of those who attended, and many felt very reluctant to start a new scientific society or association. It was generally agreed, however, that the need had become pressing, for two main reasons: the numbers of research workers who had become interested had grown so large that membership on an individual basis was clearly necessary; also, some form of organization was needed to establish and maintain liaison nationally and internationally with bodies having similar or related interests. It was resolved, therefore, that an Association be formed.

The Visiting Club originally sprang from a desire on the part of scientists of different disciplines to meet together in each others' laboratories to discuss topics of mutual interest in the field of radiobiology in which they were working. The meetings of the Club have shown that the subject of radiobiology is broad enough to bring together a group of convenient size. It is probable that other branches of radiation research such as radiation chemistry could do the same. The issue most keenly debated at the recent meeting was whether the organization which the meeting proposed to bring into being should be an Association of people who were meeting primarily on the common ground of radiobiology—with the corollary that similar group organizations would be established for other branches of radiation research—or whether an attempt should be made to establish an organization which would meet the needs of all radiation research workers. As the name of the Association implies, the latter alternative was chosen, and one of the objects of the new Association was defined as being: "To bring together research workers of different disciplines, having a common interest in radiobiology, radiation chemistry and radiation physics".

It was the express wish of those present at this and previous meetings of the Visiting Club that the scientific business of the Association should be "conducted mainly according to the precedent set by meetings of the Radiation Research Visiting Club which have been held before the formation of the Association", and this proviso was incorporated in the constitutional rules which were agreed upon as a minimum operational requirement. From now on, however, the privilege of attending these meetings will be reserved for members of the Association.

Other constitutional rules were decided on which defined the conditions for eligibility to membership—"any person actively interested in the fields covered by the objects of the Association shall be eligible for election to membership"—and the composition of the committee, which everyone agreed should include radiation research workers from varied fields of interest. The first committee, elected for a two-year period, is as follows: chairman, Dr. L. H. Gray; honorary secretary, Miss T. Alper, Experimental Radiopathology Research Unit, Hammersmith Hospital, Ducane Road, London, W.12; honorary treasurer, Dr. C. L. Smith; ordinary members, Prof. A. Charlesby, Prof. F. S. Dainton, Dr. Alma Howard, Dr. J. F. Loutit, Prof. J. S. Mitchell, Dr. Edith Paterson.

The annual subscription was fixed at 10*s*., and it was agreed that anyone who has attended any of the seven meetings of the Radiation Research Visiting Club should qualify for membership without election. Any others wishing to join the Association should be proposed and seconded by members who know them personally. Forms for the purpose may be obtained from the honorary secretary and should be returned by the proposer with accompanying letter of recommendation. It is hoped that the first election of new members will take place at a business meeting which will be held in conjunction with the first scientific meeting of the Association. This will probably take place early in 1959, in Newcastle on Tyne, at the invitation of Prof. J. Weiss. Particulars will be circulated in due course to all who have become members of the Association by the appropriate time.

Most radiation research workers have affiliations with learned societies in their own specialty. The Visiting Club has never duplicated the activities of any learned society, but has set out to bridge the gaps between different disciplines. If, in its larger context, the Association can foster an exchange of knowledge and experience in the same friendly and intimate way as the Club has done, we feel that its future is assured.

L. H. GRAY
TIKVAH ALPER

FRITZ LONDON AWARD

THE fifth International Conference on Low Temperature Physics and Chemistry, held at the University of Wisconsin during August 26–31, 1957, was the occasion of the presentation of the first Fritz London Award. The Award is to be made biennially and carries an honorarium of 1,000 dollars, together with an expense allowance of 500 dollars. The recipient was Dr. N. Kurti, of the Clarendon Laboratory, Oxford, and the texts of the introductory remarks made by Dean F. G. Brickwedde (Pennsylvania State University) and by Prof. J. G. Daunt (Ohio State University), who made the presentation, together with the address entitled "Nuclear Orientation and Nuclear Cooling" delivered by Dr. Kurti, are printed in the March 1958 issue of *Physics Today*. In a preceding article in the same issue, Dr. J. Wilks (Clarendon Laboratory, Oxford) gives a report of the general proceedings of the conference.

In his remarks, Dean Brickwedde paid tribute to Fritz London for his wide range of contributions to physics and for his philosophical approach to research. He thanked Arthur Little, Inc., for their generosity in sponsoring both the first and second Fritz London Awards, and mentioned that much of the great expansion in cryogenic research since the end of the Second World War was due to this firm because of its manufacture and improvement of the Collins helium cryostat. Prof. Daunt briefly outlined Dr. Kurti's accomplishments in the field of low-temperature physics, referring especially to his investigations at temperatures less than 1° K.

Dr. Kurti, in his address, explained first the essential connexion between nuclear orientation and cryogenics, and then summarized the four basic equilibrium methods of nuclear orientation—magnetic hyperfine structure alignment, magnetic hyperfine structure polarization, external field polarization, and electric hyperfine structure alignment. All four methods have been realized experimentally, the first both at Oxford and Leyden initially in 1951, the second in Oxford about a year later, and the third and fourth in Oak Ridge in 1955 and 1956, respectively. The nuclear orientation experiments had as their chief aim the study of the anisotropy of the gamma-ray emission in a variety of radioactive decay schemes, and by combination of the results with data obtained by conventional nuclear physics methods and by paramagnetic resonance, the decay schemes of some twenty nuclei have been established. Dr. Kurti particularly directed attention to the recent celebrated experiment on parity conservation carried out by E. Ambler, R. W. Haywood, D. D. Hoppes, R. P. Hudson and C. S. Wu at the National Bureau of Standards, pointing out that this had required considerable skill in cryogenics and had brought nuclear orientation methods into the limelight.

Dr. Kurti then turned to consider how nuclear orientation could help in solid state physics, and gave two examples of how, if the decay scheme and hence the gamma-ray anisotropy to be expected is known, the oriented radioactive nuclei may be used as indicators for certain properties. Finally, he dealt in some detail with nuclear cooling, that is, the production of very low temperatures by isentropic demagnetization of polarized nuclei. The idea was first mentioned explicitly in 1933 by C. J. Gorter, and by N. Kurti and E. F. Simon, and the possibilities of attaining the very large values of H_i/T_i (initial magnetic field and temperature) required were discussed by Simon in 1939. The final successful experiments were performed in 1956 (see *Nature*, **178**, 450; 1956), and Dr. Kurti described in his address the four steps in a magnetic cooling experiment; the construction of a suitable cryostat for nuclear cooling using magnetically cooled manganous ammonium sulphate, and the results of a series of nuclear demagnetizations all starting from $T_i = 0{\cdot}012^\circ$ K. and from fields, H_i, ranging between 3·5 and 28 kilo-œrsteds. The lowest temperature measured was about 20 microdegrees. It should be possible, Dr. Kurti asserted, to increase the value of H_i/T_i four or five times, thus reducing the nuclear entropy by about 40 per cent from its ideal value. The demagnetization would then lead to a temperature below the nuclear Curie point and the nuclear ordering could be ascertained. Another worth-while problem would be the cooling of other substances into the microdegree temperature range, and it would seem that on theoretical grounds alone there should be no fundamental difficulty. Thus eventually, Dr. Kurti forecast, microdegrees would assume a similar place in cryogenics to that occupied by millidegrees to-day.

S. Weintroub

RESEARCH FOR INDUSTRY

UNDER the title "Research for Industry"*, the Department of Scientific and Industrial Research has published a useful summary of the work done by the industrial research associations which the Department assists with grants, covering the fifteen months ended December 30, 1957. "Research for Industry", which corresponds with the summary that formerly occupied about one-third of the Department's annual report, will in future be published separately for each calendar year and generally appears to follow the pattern of its predecessor. Although it gives an interesting picture of the many-sided contribution which the research associations are making to the national life, it does not—and a summary of this character could scarcely be expected to—facilitate assessment of the place of the movement in industry, or its strength or weakness in relation to other institutions, whether from the point of view of research, of education, or of the dissemination of information.

Although most of the research associations issue annual reports, a few points of general interest may be noted to illustrate the wide scope of the movement. The British Baking Industries Research Association, for example, is examining a new milling technique which permits the alteration by mechanical means, to a greater extent than previously, of the protein/starch ratio in the several flour fractions produced, and promises to permit the production from relatively poor quality flour of fractions suited for specialized purposes. The British Boot, Shoe and Allied Trades Research Association has made good progress with new methods of training operatives whereby girls may be fully trained in six weeks. The British Cast Iron Research Association's work on de-phosphorizing foundry iron, which should permit greater use to be made of British ores high in phosphorus for making iron castings, has reached a promising stage.

The British Ceramic Research Association, which in the past few years has made a particular study of the control of dust in those processes in which the health of the operative is at hazard, and has succeeded in controlling dust in the towing and fettling of earthenware on an industrial scale, is now focusing attention on the corresponding problems in the sanitary earthenware and tile industries. The British Coal Utilization Research Association has developed a new design of ash pan for railway locomotives for use with inferior coal, while the British Coke Research Association is seeking the best methods for disposing of liquid effluent from coke-oven plants and establishing the standards of purification required for effluents which are disposed of to rivers and sewers.

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* Department of Scientific and Industrial Research. Research for Industry: a Summary of work done by the Industrial Research Associations in the Government Scheme, 1956–57. Pp. iv+159. (London: H.M. Stationery Office, 1958.) 7*s*. 6*d*. net; 1.35 dollars.

The automatic hardening machine designed by the Cutlery Research Council to reduce the labour required for the operation to 25 per cent of that needed for the conventional method represents the Council's first major attempt at mechanization. Machines developed for the classification of fine powders, depending on the opposing action of centrifugal force and inward air-drag, have been used by the Research Association of British Flour-Millers to make cuts in flour at production-rates of commercial interest, giving, for example, a higher protein half of better bread-making quality and the other half of better cake-making quality than the original flour. Large-scale canning trials by the Fruit and Vegetable Canning and Quick Freezing Research Association indicate that the antibiotic, nisin, has potential application in controlling the spoilage of canned vegetables by heat-resistant thermophilic bacteria.

Besides devising apparatus to determine at any time the stage to which glass melting has proceeded, the British Glass Industry Research Association has given much attention to the role of instrumentation and automatic control of furnace conditions, while electronic methods devised by the Hosiery and Allied Trades Research Association have enabled lengths of stockings to be controlled automatically within very close limits. A simple investigation of flow in small open channels by the British Hydromechanics Research Association has permitted the designer to reduce the number of down pipes in a length of building by one-half and has also pointed to a slight modification of the outlet design which can double the capacity of the system.

The British Iron and Steel Research Association has applied the statistical technique of regression analysis to establish correlations between the many factors that affect the performance of blast furnaces, and the British Jute Trade Research Association has developed an anti-corrosive wrapping material for bright steel parts. The Motor Industry Research Association is investigating a promising method of reducing noise in vehicles by damping the vibration of body panels, and the work of the Research Association of British Paint, Colour and Varnish Manufacturers has included the structural features of paint films, the molecular make-up of the medium in film form and the character and disposition of the pigment particles.

An entirely new process for the production of paper pulp from graminaceous raw materials, devised by the British Paper and Board Industry Research Association, gives greatly increased yields, and the Printing, Packaging and Allied Trades Research Association continued its study of the hazards of transport and how packages stand up to them. The British Rayon Research Association has put on the market the warp tension balance, which enables the loom overlooker to control the incidence of repping, and an electronic tensiometer, for the correct setting of yarn spinning and processing machinery; and a study of productivity in the process of mastication and mixing by the Research Association of British Rubber Manufacturers has greatly increased production.

In its methodical tests on models of ocean-going merchant vessels, the British Shipbuilding Research Association is giving much attention to the problem of hull roughness. The Coil Spring Federation Research Organization is studying the effect of variations in manufacture and materials on the fatigue life of heavy suspension springs, and the British Steel Castings Research Association has started a long-range investigation on the factors determining the efficient utilization of oxygen in electric furnace steel-making. The Coal Tar Research Association has given particular attention to factors influencing the purification of naphthalene by fractionation and by crystallization.

AIRFLOW OVER MOUNTAINS

IT has been recognized for many years that regular patterns of motion of a wave-like type may occur in the air flowing over and to the lee of mountain ranges. This seems to have been realized first from the clouds which—given suitable conditions of temperature and humidity—form in the ascending currents of the waves and which are more or less stationary although obviously situated in a strong wind. The rising and falling components of wind in these waves are of importance to aviation as they may cause the aircraft to rise, or more important, descend in a dangerous manner. They have frequently been used by glider pilots as a means of ascent. The wave patterns can occur at considerable distances above and beyond the mountain range responsible and must be distinguished from the irregular turbulent flow set up in the immediate vicinity of the peaks and steep parts of the mountains. The waves are most readily produced by long ranges transverse to the wind.

Much theoretical study has been devoted to the mechanics of the waves in the past twenty years, the most successful theory being due to Dr. R. S. Scorer of the Imperial College of Science and Technology, London. Dr. Scorer's theory has been well verified by the experiences of aircraft pilots and other observations, so that it now appears justifiable for aviation weather forecasters to use it in attempting to predict the occurrence of waves.

Dr. Scorer showed that waves will form only if the vertical gradient of temperature and wind speed in the air to windward of the range are suitable. His theory in fact states that waves will form if the quantity termed l^2, which is given by:

$$\frac{g}{T}\,\frac{\left(\Gamma + \frac{dT}{dz}\right)}{U^2} - \frac{1}{U}\,\frac{d^2U}{dz^2}$$

(where T is the absolute temperature, Γ is the numerical value of the dry adiabatic lapse-rate, U is the wind speed, and Z the height), decreases with height. In fact, and fortunately, the difficult second term is of small account compared with the first term, which can be calculated with sufficient accuracy from observations.

From the formula, considering only the first term, it follows that waves are to be expected if the temperature gradient decreases (lapse-rate increasing, in the usual meteorological terminology) with height, or wind speed increases, or there is a suitable combination of both effects.

In Meteorological Report No. 18*, Mr. G. A. Corby of the Meteorological Office describes how Dr. Scorer's theory can be exploited by forecasters when advising pilots on the nature of the airflow over mountains. He gives a number of reports of waves encountered by aircraft, and shows how the occurrence of the waves in question was to be expected from the atmospheric structure. A suitable diagram for computing l^2 is given with instructions for its use in forecasting.

The report also contains diagrams of the flow of air in lee waves computed from the general theory and an account of such effects as the increase in liability to ice formation, given suitable air temperature and humidity, in the waves because the ascent of the air has the effect of lowering the height of the freezing-level.

G. A. Bull

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* Air Ministry: Meteorological Office. Meteorological Report No. 18: Air Flow Over Mountains—Notes for Forecasters and Pilots. By G. A. Corby. Pp. ii+53. (London: H.M. Stationery Office, 1957.) 3s. net.

MOUNT STROMLO OBSERVATORY

REPORT FOR 1957

The annual report of Mount Stromlo Observatory for 1957* deals first with the transfer of the Observatory to the Australian National University on January 3, 1957, when the Commonwealth Observatory of the Department of the Interior officially ceased to exist. All the members of the scientific staff of the Observatory were transferred to the Department of Astronomy of the Research School of Physical Sciences of the Australian National University, the official name of the Observatory then becoming 'Mount Stromlo Observatory'. Arrangements were made not only to safeguard the financial status of the staff but also to protect an area of about 3½ square miles in which the Observatory buildings are situated "from invasion by industry, commerce or any development relating to the growth of the nearby capital city of Canberra".

Following the departure of Dr. R. v. d. R. Woolley in December 1955, Dr. A. R. Hogg assumed the post of acting director of Mount Stromlo Observatory, a position which he retained until Dr. Woolley's successor, Dr. B. J. Bok, took office in March 1957, and on his arrival became head of the newly formed Department of Astronomy at the Australian National University. Tribute is paid to the valuable work accomplished during Dr. Hogg's tenure of office, and on Dr. Bok's arrival he was appointed assistant director.

Tests of the 74-in. mirror by Dr. Hogg, with the assistance of Mr. K. Gottlieb, proved the existence of astigmatism in excess of the maximum permissible amount, and while steps are being taken to remedy this, the telescope during the interim is used for photoelectric, spectrographic and photographic work. Under Dr. Hogg's direction the mirror was successfully aluminized. The 50-in. Melbourne reflector has been overhauled in the Design Department and the workshop. Motorization of the fast motion in right ascension has been completed and provisions have been made for Selsyn repeater systems in both declination and right ascension. Other alterations have been made and an important work plan is well under way to replace the present $f/2$ spherical primary with an $f/4{\cdot}5$ paraboloid and a conventional Cassegrain mirror for the entire system to operate at $f/18$. The 30-in. Reynolds reflector, which continues to be in regular use, is overdue for a complete mechanical and electrical overhaul. Short notes appear on the other instruments, including the 20-in. Catts reflector, the 8-in. $f/1$ Schmidt, and the photographic zenith tube, and considerable space has been devoted to Dr. T. Dunham's plans for a coudé spectrograph on the 74-in. reflector. The spectrograph will be enclosed in a housing with double walls 24 ft. long and 16 ft. wide, and air at constant temperature will circulate between the two layers of the wall, thereby avoiding thermal effects on the instrument.

Among other matters dealt with are observation of artificial Earth satellites. It is emphasized that Mount Stromlo Observatory is not officially involved in the observation of artificial satellites and the names of other institutions and also individuals are referred to in connexion with this work. Nevertheless, *Sputnik I* was kept under observation, and later Dr. A. Przybylski carried out observations of other satellites and did a considerable amount of work on their orbits. He also issued duplicated copies of predicted times of observation which proved to be very reliable.

Eight vacation scholars selected from undergraduate students in physics and mathematics at the Universities of Melbourne, Adelaide, Queensland and Sydney were appointed for the summer months, and each scholar has been assigned as a special assistant to a staff member. These scholars hold weekly colloquia, attend weekly informal discussion meetings, and participate in the night observing, acting as night assistants on the 74-in. reflector during staff vacations. They live in University House, conduct the visitors around during the day-time and participate fully in many other Observatory activities. It is hoped that during 1958 the first appointments will be made to regular scholarships leading to the Ph.D. degree.

Public visits to the Observatory both by day and night have been remarkably popular; to accommodate the great demand for visits by night the Director has instituted a series of monthly visitors' nights, with an average attendance of 150 people, and on these nights most telescopes are open for inspection. Estimates of the number of visitors show that there have been about 3,500 day-time visitors, 500 Wednesday visitors and 1,000 visitors during the seven special evenings. A booklet has been issued which gives information about the Observatory and its work. A list of the names of the twenty-two members of the Observatory staff and a catalogue of papers published during 1957 appear at the end of the report.

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* Australian National University: Mount Stromlo Observatory. Annual Report for the Year 1957. Pp. 22. (Canberra: Australian National University, 1958.)

A SIMPLE TECHNIQUE FOR INOCULATING PATHOGENIC BACTERIA ON SUSCEPTIBLE PLANT LEAVES

By M. A. NOUR and J. J. NOUR

Faculty of Agriculture, Shambat, University of Khartoum, Republic of the Sudan

DURING an investigation of virus diseases of 'lubia' (*Dolichos lablab* L.) an extract of the virus-infected leaves was mixed with a small amount of 'Carborundum' (300 mesh) and rubbed on healthy leaves in the normal way. It was observed that when the leaves used as a source of inoculum contained a few lesions of bacterial disease, numerous lesions of the bacterial infection developed on the rubbed leaves. The causal agent was the *Dolichos* strain of *Xanthomonas phaseoli* (Smith) Dowson[1].

Several inoculation tests were made by rubbing either the crude extract (in 10 ml. water) of 10 gm. fresh weight of *Dolichos* leaves infected with *X. phaseoli* or by rubbing a suspension of the pure culture of this pathogen on to healthy leaves of 'lubia' with ($+ C$) or without ($- C$) 'Carborundum' in both cases. The 'undiluted' suspension was obtained by adding 7 ml. distilled water to a 'slope' of 10 ml. yeast-extract agar upon which the pure culture was grown. By scraping and shaking, the yellow turbid suspension was obtained. In another experiment, different dilutions of the crude extract or of a 2–3 day old pure culture suspension were separately mixed with an equal volume of a 1 per cent solution of anhydrous sodium sulphite[2], or with water (as control), and were rubbed on to healthy leaves. This test was made to confirm the earlier observation that a larger number of bacterial spots formed when sodium sulphite, rather than when water, was used with the leaf extract.

In a third series of tests, other related species were rubbed with the crude extract from *Dolichos* leaves heavily infected with *X. phaseoli*, namely, *Phaseolus vulgaris* L., *Canavalia ensiformis* (L.) DC., *Vigna unguiculata* (L.) Walp., *Cajanus cajan* L., *Lupinus termis* Forsk. and *Crotallaria saltiana* Andr.

'Carborundum' in all comparable tests gave a large number of bacterial lesions, many more than in the controls (Table 1). When 'Carborundum' was used, the typical water-soaked lesions appeared after 5–7 days, as compared with 7–10 days when it was not.

The results obtained did not confirm the original observations that sodium sulphite induces the formation of significantly more local lesions than water. Very similar results were obtained with young Domain Sakel cotton plants (*Gossypium barbadense* L.) and a pure culture suspension of *Xanthomonas malvacearum* (Smith) Dowson (Table 2). When 'Carborundum' was used, with both 'lubia' and cotton, a significantly larger number of lesions developed in areas that were mechanically injured than on the apparently undamaged parts.

Table 1. EFFECT OF 'CARBORUNDUM' USED WITH INOCULUM IN RUBBING HALF LEAFLETS OF *Dolichos lablab*

Dilution	Lesions per half leaflet			
	With sodium sulphite		With water	
	$+ C$	$- C$	$+ C$	$- C$
1 : 1	584	33	463	31
1 : 2	388	50	250	25
1 : 4	520	44	300	27
1 : 8	300	26	240	16

Table 2. EFFECT OF 'CARBORUNDUM' WHEN USED WITH INOCULUM IN RUBBING HALF LEAVES OF EGYPTIAN COTTON

Dilution	Lesions per half leaf			
	With sodium sulphite		With water	
	Dec. 5	Dec. 9	Dec. 5	Dec. 9
1 : 1	50	340	58	360
1 : 10	131	525	66	355
1 : 10*	3	26	0	23
1 : 100	16	142	51	190

* $- C$.

In the third series, only *D. lablab* showed symptoms of infection. This *Dolichos* strain is specialized enough, therefore, not to cause an infection (or even sub-infection) even when 'Carborundum' is used.

To compare this technique with the standard methods of inoculating bacteria on leaves[3], several tests were done. In one, the first leaves of young *Dolichos* plants were sprayed with a 1 : 1 or 1 : 10 suspension of the bacteria from pure culture, leaving one lot of each in the open and covering the others with bell jars. On another set of first leaves the same dilutions were rubbed, with or without 'Carborundum'. The water-soaked lesions appeared on the leaves treated with 'Carborundum' 4–6 days before those sprayed and covered (Table 3). Again, similar results were obtained when the two methods were applied on young cotton plants, using *X. malvacearum*.

Table 3. EFFECT* OF SPRAYING AS COMPARED WITH MECHANICAL RUBBING ($+ C$) OF INOCULUM ON WHOLE LEAVES OF *D. lablab*

Dilution	Sprayed		Rubbed
	In bell jar	Open	$+ C$
1 : 1	38	16	> 1,000
1 : 10	14	2	> 1,000

* Average number of lesions per whole first leaf (10 replications) caused by *X. phaseoli*.

This new technique for bacterial inoculation has several advantages. It is highly economical with the inoculum and is simple and easy to apply. Furthermore, the use of high-humidity chambers after inoculation is unnecessary to ensure heavy infections. Another advantage is that the symptoms appear earlier than when the standard spraying method is used. However, the greatest advantage is that the pathogen can be placed exactly where it is required to form lesions of infection.

We gratefully acknowledge the assistance of Dr. K. A. Sabet, head of the Agricultural Botany Department in this Faculty, for identifying the pathogens, for supplying the pure cultures and for his valuable suggestions.

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[1] Tarr, S. A. J., "The Fungi and Plant Diseases of the Sudan" (C.M.I. Publication, 1955).

[2] Govier, D. A., *Ann. Appl. Biol.*, 45, 62 (1957).

[3] Dowson, W. J., "Plant Diseases due to Bacteria" (Cambridge University Press, 1957).

BIOCHEMICAL MUTANTS IN BACTERIA WITH IMPAIRED RESPIRATION

By Prof. G. F. GAUSE

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MUTANT strains of staphylococci, with impaired respiratory activities, have been used in the screening of antibiotics to pick out those selectively inhibiting cells with the deficient respiration[1]. These investigations, which formed part of a search for anti-cancer substances, stimulated studies on the production of similar mutations in different species of bacteria.

In *Staphylococcus aureus*, Strain 209, mutations with the respiratory deficiency were induced by ultra-violet radiation[2]. The mutants grew slowly on nutrient agar, producing small colonies which differed from the parent strain in being orange-rose in colour. Their respiration was studied, using Warburg manometry at 37° C. in a medium containing sodium chloride 0·138 *M*, sodium bicarbonate 0·003 *M*, and glucose 0·0555 *M*. Average Q_{O_2} values (μl./hr./mgm. dry weight) were: parent strain 104·0; mutant No. 2 48·0; mutant No. 3 38·1. The addition of 0·012 *M* sodium cyanide inhibited respiration of the parent strain by 86·1 per cent, whereas it inhibited that of mutant No. 2 by 45 per cent and mutant No. 3 by only 14·5 per cent. In other words, the respiratory activity of these biochemical mutants of staphylococci was greatly reduced and was also less sensitive to cyanide, relative to the parent strain[3]. These characteristics of the mutant strains have proved stable, through numerous subcultures, at least for a period of one year.

It is remarkable that the parent culture of staphylococci and the two mutants obtained from it do not differ from each other in their sensitivity to penicillin and to streptomycin, whereas albomycin only inhibits growth of the parent culture and is no longer active against either mutant culture[2]. This is probably related to the fact that albomycin inhibits the growth of bacteria only in the presence of oxygen[4]; perhaps mutant cultures of staphylococci with the impaired respiration no longer possess a specific receptive substance affected by albomycin.

Spectroscopic studies with a Zeiss microspectroscope have shown that, whereas in the parent strain three α bands of cytochromes are distinctly visible (strong b_1 band at 560 mμ, and two smaller bands, *a* at 605 mμ and a_2 at 625 mμ), in both mutant strains band b_1 is no longer visible[3].

Further studies have shown that in *Bacterium coli* and *Bacterium paracoli* biochemical mutations with impaired respiration could also be obtained[3,5]. They are induced by ultra-violet radiation and particularly by urethane, which, as is well known, has a strong carcinogenic action upon the cells of higher animals and inhibits cytochrome electron transport. On nutrient agar, containing 2 per cent urethane, a few rare mutants can be found with the hereditary impairment of respiration among slowly growing colonies of parent culture. These mutants grew slowly on nutrient media without urethane, and have not changed their characteristics in subcultures for a long period of time.

The impairment of respiration in these mutant strains is clearly seen from the following data[3,5]:

	Q_{O_2}
B. coli, parent culture 5383	138·5
B. coli, ultra-violet mutant 8	62·7
B. coli, parent culture 5375	178·0
B. coli, ultra-violet mutant 9	63·7
B. paracoli, parent culture	173·0
B. paracoli, urethane mutant 52–1	42·0
B. paracoli, urethane mutant 52–2	40·5
B. paracoli, ultra-violet mutant 12	36·0
B. paracoli, ultra-violet mutant 15	43·8
B. paracoli, ultra-violet mutant 17	54·2

The respiration of these mutants is also less sensitive to inhibitory action of 0·012 *M* sodium cyanide as compared to their parent strains[3]. Microspectroscopic examination of thick suspensions of living cells of these mutants produced some very instructive results, shown in Fig. 1.

The parent strains of both *B. coli* and *B. paracoli* possessed three distinct α bands, namely, a_2 at 625 mμ, *a* at 605 mμ, and the strong b_1 band at 560 mμ. In all mutant strains the intensity of the *a* band was strongly increased, and in some of them it was shifted from 605 to 600 mμ. Most important of all, however, was the fact that the b_1 band at 560 mμ had disappeared in all mutant cultures, and was

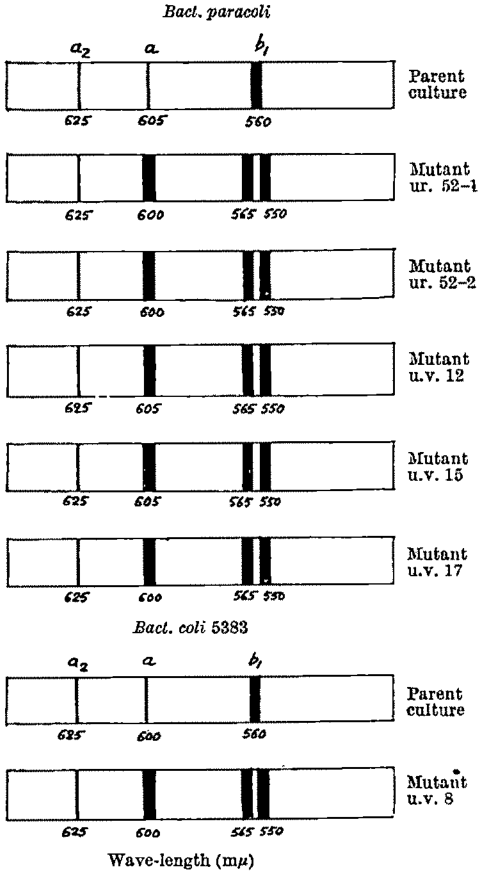

Fig. 1. Cytochrome spectra in parent cultures of *B. coli* and *B. paracoli*, and in six mutations with the impaired respiration obtained from them

actually replaced by two new strong bands, at 550 and 565 mμ. In view of suggestions[6] that the cytochrome b_1 band in *B. coli* results from the fused bands of cytochromes *b* and *c*, the appearance in the mutant with impaired respiration of two new strong bands in the *b* and *c* positions, instead of the characteristic b_1 band of the parent culture, is very remarkable. These characteristic alterations in cytochromes of the mutant cultures of *B. coli* and *B. paracoli* evidently accompany the functional inefficiency of their respiratory system, as it can be judged by the low value of Q_{O_2} and by the decrease of cyanide sensitivity of the oxygen consumption.

Mutant cultures with the impaired respiration in *Bacillus mycoides* (smooth form) were also obtained[5]; they were induced by the combined action of ultra-violet radiation and of urethane. Values of Q_{O_2} at 28° C. were: parent strain 52·8; mutant No. 2 37·0; mutant No. 4 43·3. The respiration of mutant strains was also less sensitive to the inhibition by cyanide as compared to the parent strain—for example, 0·012 *M* sodium cyanide inhibited respiration of the parent strain by 68·5 per cent, mutant No. 2 by 19 per cent, and mutant No. 4 by 30·5 per cent.

Spectroscopic studies showed that the parent culture of *B. mycoides*, in common with many other aerobic spore-forming soil bacteria, possessed the following α bands in its cytochrome spectrum: *a* band at 603 mμ, and two wide bands, almost merging, *b* at 563 mμ, and *c* at 552 mμ. In both mutants of *B. mycoides* with impaired respiration, the *b* band of cytochrome at 563 mμ was no longer visible; the *a* and *c* bands remained essentially the same as in the parent culture.

The mutants in staphylococci, *B. coli* and *B. paracoli* and in *B. mycoides* with impaired respiration, all share the following common features: decreased Q_{O_2} values, and a diminished sensitivity of their respiration to cyanide. However, their respiratory deficiencies are accompanied by different alterations of the cytochrome systems in different bacteria; in staphylococci the cytochrome b_1, and in *B. mycoides* the cytochrome *b*, are no longer visible. In *B. coli* and *B. paracoli* the band of cytochrome b_1 disappears, and two new bands appear in its stead. It is remarkable in this connexion that in the intact ascites tumour cells in mice with impaired respiration[7], spectroscopic study[8] has also revealed a deficiency in cytochrome *b*.

A plea has recently been made for a more rational approach in chemotherapeutic research[9]. Bacterial mutants with impaired respiration seem to represent, in this connexion, very convenient tools for detection of antibiotics and of other substances selectively inhibiting cells with deficient oxidative powers; such substances present interesting therapeutic potentialities, particularly in cancer research.

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PIGMENTS AND PHOTOSYNTHESIS IN A CAROTENOID-DEFICIENT MUTANT OF *CHLAMYDOMONAS*

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THERE are many reports in the literature of mutations affecting the formation of chlorophyll and carotenoid pigments[1]. In general, these mutations decrease the chlorophyll content either independently of, or concomitant with, a lowered carotenoid content. Similarly, environmentally induced alterations of pigment content have involved decreases in chlorophyll relative to carotenoid. Many non-green plant tissues contain large amounts of carotenoids. However, no instance has been reported, to our knowledge, in the algae or in higher plants, of the formation or occurrence of chlorophyll in the absence of carotenoids. (In the photosynthetic bacterium *Rhodopseudomonas spheroides*, blue-green mutants have been described which contain bacteriochlorophyll and no coloured carotenoids[2].)

This article describes a pale-green mutant strain of the alga *Chlamydomonas reinhardi*, which contains chlorophyll but only traces of carotenoids. This strain, No. 95, and several others which resemble it, were recovered after ultra-violet irradiation of normal green cells. These strains are very stable, no reversion to normal green having appeared at any time since the initial isolation, either in stock cultures or in the many litres grown for pigment analysis. Because of the poor growth-rate of these strains, it is probable that reversions to or towards wild type would have a selective advantage, and therefore would have been readily detected had they occurred.

Preliminary examination with the electron microscope[3] of the pale-green mutant has revealed the presence of a chloroplast in which the total amount of lamellar surface is greatly reduced from that of the normal green strain[4]; only a few scattered lamellar membranes are present. In studies using the double-beam spectrophotometer[5] it was determined that the mutant responds to illumination by uptake of carbon dioxide, release of oxygen, and oxidation of respiratory enzymes including cytochromes of the *b* and *f*-types. Thus, the pale-green mutant carries out photosynthesis. Its photosynthetic efficiency, on a chlorophyll basis, is greater than that of the wild type. None the less, the mutant dies when grown in the light, whether cultured photosynthetically on a minimal medium or heterotrophically on a medium which supports its growth in the dark.

In view of the many questions as yet unresolved concerning the role of carotenoids in photosynthesis, in the structural organization of the chloroplast lamellæ, and in protection from the lethal effects of

Table 1. CAROTENOID CONTENT OF NORMAL GREEN AND PALE-GREEN STRAINS OF *Chlamydomonas*

Name of pigment		Absorption maxima in ethanol†			Quantity (mgm./gm. protein)* Normal green (light-grown)	Normal green (dark-grown)	Pale-green (dark-grown)
Hypophasic	*A* (Auroxanthin)	427·5	403	(382)	0·191	—	
	B (Diadinoxanthin)	476	448	(420)	0·299	—	
	C (Flavoxanthin)	453	427·5	(404)	0·105	—	
	D	469	441	(418)	0·105	0·288	
	E	475	446	(423)	0·099	0·352	
	F	475	451	(425)	0·039	—	
	Xanthophyll	474·5	446	(423)	0·303	4·270	
Partially hypophasic	*H*	475	446	(423)	0·178	—	
	I	462	439	(415)	0·063	—	
Epiphasic	*J*	(475)	445		0·046	—	
	K	486	457	(435)	0·296	0·492	
	L	(475)	447	(428)	0·132	—	
	M	436	411	(390)	0·118	—	
	β-Carotene	476	450		3·530	7·930	0·0192
	α-Carotene	473	444		0·181	0·494	0·0067
Total carotenoid					5·69	13·83	0·0259
Total carotenes					4·30	8·92	0·0259
Per cent carotenes					75·8 per cent	64·5 per cent	100 per cent
Per cent β-carotene					62 per cent	57·3 per cent	74·1 per cent

* These values can be converted approximately to mgm./100 gm. dry weight by the factor 25.
† Values in parentheses refer to an inflexion in the spectrum rather than a peak.

light, it was of particular interest to determine the carotenoid content of this pale-green strain. There are no reports in the literature concerning the carotenoids of *Chlamydomonas*, except for those of Moewus on protocrocin and its derivatives[6]. The carotenoids of *Haematococcus*, a closely related genus, have been studied by Tischler[7] and by Goodwin[8]; *b*-carotene and xanthophyll are predominant in the green stages, while the red cysts contain mainly astaxanthin. In addition, there are minor pigments, of which aphanin, aphanizophyll and violaxanthin have been identified.

This article reports the chlorophyll and carotenoid content of the pale-green strain in comparison with that of the normal green strain from which it arose. The major carotenoids were separated by chromatography and identified, and the minor pigments were characterized by their spectra and chromatographic behaviour.

Cells were grown for pigment extraction in liquid medium, containing acetate and inorganic salts[9], and harvested by centrifugation at the end of the logarithmic phase of growth, at densities of 1–5 × 10^6 cells/ml. for the pale-green, and about 1 × 10^7 cells/ml. for the normal green strain. The starting material for carotenoid extraction contained, in the normal green strain grown in light, 152 mgm. protein, in the dark-grown normal green, 35 mgm. protein, and in the pale-green mutant, 240 mgm. protein. Protein was estimated, after acetone extraction, by the biuret reaction and compared with a standard of bovine albumen[10]. Chlorophyll was extracted from washed fresh cells with 85 per cent acetone; optical density was determined in acetone with a Beckman spectrophotometer, and total chlorophyll computed by the method of McKinney[11].

Carotenoids were extracted from fresh frozen cells with methanol, saponified with potassium hydroxide and transferred to hexane. Epiphasic and hypophasic pigments were separated by shaking the hexane solution with 90 per cent methanol. Epiphasic pigments (carotenes) were chromatographed on magnesium oxide and developed with 10 per cent acetone-hexane. Hypophasic pigments (xanthophylls) were chromatographed on calcium hydroxide and developed with 10 per cent acetone-hexane containing 1 per cent ethanol. All pigments were rechromatographed and their spectra taken with a recording spectrophotometer.

b-Carotene was obtained in crystalline form and identified by its spectrum and by a mixed chromatogram with a known sample. Xanthophyll was identified by its spectrum, partition behaviour, and by a mixed chromatogram with a sample obtained from spinach; *a*-carotene was identified by its spectrum and chromatographic behaviour. Other pigments could not be identified positively, and the spectra of some are different from those of any known carotenoid.

The chlorophyll and carotenoid content of the pale-green mutant was compared with that of the normal green strain grown both in the light and in the dark; the same acetate medium was used throughout. The carotenoid pigments recovered are listed in Table 1, in decreasing order of adsorption on the chromatographic columns. Concentrations were calculated from known extinction coefficients, and in the instance of unknown pigments, the extinction coefficients *E*(1 per cent, 1 cm.) were assumed to be 2,500 at the absorption maximum.

The pale-green mutant was found to contain less than 0·5 per cent of the total carotenoid of the light-grown normal green strain, and less than 0·2 per cent of the carotenoid of the dark-grown normal green. This trace of carotenoid consists of *a*- and *b*-carotene; no other constituents were detected.

No phytoene or phytofluene was found in either pale-green or normal green cells. They would have

Table 2. CHLOROPHYLL CONTENT AND CHLOROPHYLL–CAROTENOID RATIOS OF NORMAL GREEN AND PALE-GREEN STRAINS OF *Chlamydomonas*

	1 Normal green (light-grown)	2 Normal green (dark-grown)	3 Pale-green (dark-grown)	Ratio 1/3	Ratio 2/3
Chlorophyll conc., moles/gm. protein	$1·55 \times 10^{-4}$	$1·02 \times 10^{-4}$	$8·61 \times 10^{-6}$	18	8·5
Total carotenoid, moles/gm. protein	$1·05 \times 10^{-5}$	$2·58 \times 10^{-5}$	$4·84 \times 10^{-8}$	217	533
Ratio chlorophyll/carotenoid	14·8	3·96	178		
β-Carotene, moles/gm. protein	$6·58 \times 10^{-6}$	$1·48 \times 10^{-5}$	$3·58 \times 10^{-8}$	184	413
Ratio chlorophyll / β-carotene	23·6	6·9	241		

been detected if present in concentrations as low as 10 μgm. per gm. protein. Astacene, which would have been derived from astaxanthin with the extraction procedure used, was also absent.

Light-grown normal green cells were found to contain a number of carotenoid pigments, with *b*-carotene as the major constituent, and others present in small amounts. In dark-grown normal green cells, there was more than twice as much carotenoid present as in light-grown cells, with the bulk of it, too, consisting of *b*-carotene. However, few of the other pigments were found; one component, xanthophyll, was predominant. Thus, it appears that either light or some step in the photosynthetic pathway enhances the formation of a number of minor pigments, possibly at the expense of xanthophyll.

Data on chlorophyll concentration of the two strains are given in Table 2, together with comparisons of chlorophyll/carotenoid ratios. Despite the low chlorophyll content of the pale-green mutant, it is noteworthy that its chlorophyll/carotenoid ratio is still much higher than that of the normal green strain, because of its exceedingly low carotenoid content.

It was estimated[11] that about 60 per cent of the chlorophyll of normal green cells is present as chlorophyll *a*; the rest is *b*. In the pale-green mutant, about 90 per cent of the total is chlorophyll *a*.

The pale-green mutant which was the subject of this study has about 1/15 the chlorophyll and less than 1/200 the carotenoid content of the normal green strain from which it was derived by mutation. This decreased pigment content and high chlorophyll/carotenoid ratio does not interfere with the photosynthetic capacity of the strain. On the contrary, its 'assimilation number' (moles carbon dioxide taken up/mole chlorophyll/sec.) is higher than that of the normal green strain[5], a finding analogous to that reported by Willstater and Stoll for golden varieties of the number of plants[12].

Our findings support the hypothesis that carotenoids are not essential for green plant photosynthesis, except possibly in catalytic amounts. The occurrence of photosynthesis in the apparent absence of carotenoids has also been reported for a blue-green mutant of *Rhodopseudomonas spheroides*[2], which contains bacteriochlorophyll and the colourless carotenoid, phytoene. In discussing this mutant, Calvin[13] suggested that an essential part in photosynthesis, normally played by carotenoids, may be provided in the mutant by "the less conjugated phytoene". Since no phytoene is found in the pale-green *Chlamydomonas* mutant, this hypothesis is at present inapplicable in our material. With respect to the absence of phytoene and phytofluene, the *Chlamydomonas* mutant also differs markedly from the mutants of *Chlorella*[17] and of *Neurospora*[16], and phenocopies obtained with diphenylamine[16] which have been described.

Lynch and French[14] have provided preliminary evidence of the need for *b*-carotene or a related compound in the Hill reaction as carried out by lyophilized broken chloroplast preparations. In their experiments, Hill activity is completely lost after extraction of just a few per cent of the carotenoid. One may question, therefore, how specifically the changes in Hill activity depend upon this small change in carotenoid content, or whether the extraction and recoating process affects the system indirectly.

The pale-green mutant dies when grown in the light either photosynthetically or heterotrophically. This lethal effect of light resembles that described for the blue-green *Rhodopseudomonas* mutant[2]; and the hypothesis that carotenoids protect cells from "photodynamic destruction by chlorophyll"[2] may also apply to the pale-green mutant. On the other hand, the correlated lack of carotenoids and photosensitivity could represent independent results of some more basic deficiency.

The low carotenoid content of the pale-green strain is of interest also in connexion with structural features of the chloroplast as seen with the electron microscope. The lamellar membranes typical of the chloroplasts of all normal green cells including *Chlamydomonas*[4] are found in the pale-green mutant, although their number is much reduced. This finding contrasts with that reported for the yellow mutant of *Chlamydomonas*[15], in which lamellæ do not form in the absence of chlorophyll. When the yellow mutant is brought from dark growing conditions into light, chlorophyll synthesis is initiated and lamellar formation proceeds in parallel[3]. Thus chlorophyll is required for the formation of lamellar membranes, and probably is incorporated as a necessary component into the membranes.

In the pale-green mutant, the reduction of lamellar surface is approximately 20-fold in comparison with the normal green cell, a value which correlates better with the 10- to 20-fold reduction in chlorophyll concentration than with the 200- to 500-fold reduction in carotenoids observed. It is likely, therefore, that carotenoids are not required for the formation of lamellæ, and furthermore, may not represent an essential component of photosynthetically active membranes. In normal green cells, on the other hand, carotenoids probably are incorporated into the membranes, judging from the participation in action spectra of photosynthesis[12] of wavelengths of visible light absorbed principally by carotenoids.

On the question of stoichiometry of constituents of the membranes, it may be noted that the chlorophyll/carotenoid ratio in the pale-green mutant is almost fifty times that in the dark-grown normal green. If the few carotenoid molecules present in the pale-green strain are, in fact, incorporated into the membranes, then their arrangement with respect to the other components must be very different from that in the normal green cells.

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A STEGOLOPHODON FROM SOUTH AFRICA

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During an expedition to the Elandsfontein fossil site[1], 10 miles from Hopefield (about 60 miles north-west of Cape Town), we visited the Langebaan Phosphate Quarries (of the African Metals Corporation), which are 10 miles north-north-west of that site. Fossils are known to have been excavated during blasting operations, and on this occasion we were shown some specimens recently recovered by a prospector, Mr. I. S. Brown. This preliminary report deals with only one of these specimens. It was found in Baard's Quarry on the farm Langberg in a phosphate deposit about 15 feet below the surface. Below the sandy surface layer is a layer of phoscrete, below which is a thicker layer of clay and phosphatic nodules. Under this is a 12-in. layer of solid phosphate in which the specimen was found. Details of the geological interpretation of the stratified layers are still awaited.

Other fragments were found with the specimen being recorded, but unfortunately the prospector discarded these and a search for them is still to be undertaken. We are indebted to Mr. A. Coreejes, superintendent of the quarry, for kindly giving the specimen to the South African Museum, Cape Town. Its registered number is S.A.M. 11714.

It is a portion of a right upper molar comprising the last two ridges. The hindmost ridge is just in wear and consists of five subequal cones; the two cones on the buccal side are placed somewhat more forward than the other (Fig. 1). Behind and between the two buccal cones there is a fairly large cone, which is in line with the cones in the lingual part of the hind ridge. In turn between it and the central cone of the hind ridge there is a much smaller cone, which together with it represents the talon (Figs. 1 and 2). The posterior margin of the crown is smoothly rounded from side to side, with the base projecting backward slightly more lingually than buccally. The transverse width of the posterior ridge is 62 mm. at base; the height of the almost unworn central cones is 30 mm.

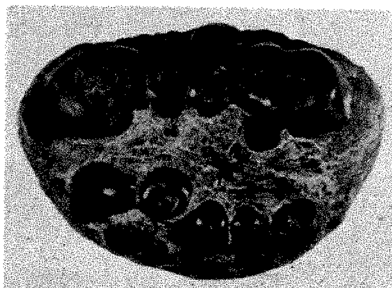
The valley in front of the hindmost ridge is closed in at the bottom. It is filled with cement that extends to the apices of the cones of the hind ridge, and there are two tiny enamel cusps at its lingual entrance (Fig. 3). The cement layer has been lost on the buccal and lingual edges of both ridges as well as on the posterior surface of the crown. There is a natural cleft in the cement limited to the lingual half of the valley between the two ridges (Fig. 1).

The second ridge from behind measures 75 mm. across the base. However, the gingival margin of the crown is incomplete on both sides of the ridge, and the full width of the ridge may have been about 80 mm. The cones of the second ridge are six in number. There are two central cones flanked by two massive cones each of which is imperfectly subdivided into a small central and a larger lateral cone. The two central cones are separated from each other as well as from the cones on each side by clefts that continue to the base of the crown (Fig. 4). The combined width of the two central cones is 18 mm. measured along the occlusal surface, the same as that of each pair of cones on either side. The apices of the dentine cores of all the six cones have just been reached by wear; the ridge is slightly more worn down on the buccal than on the lingual side. The maximal height of the worn ridge is 35 mm. The slope of the buccal edge of the ridge is less steep than that of the lingual edge; this effect is produced by a bulge towards the base of the buccal part of the crown (Fig. 1).

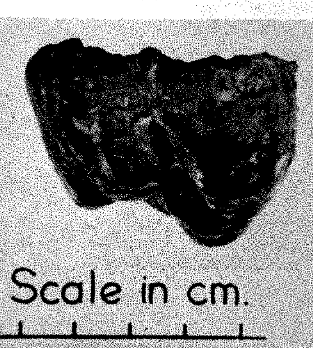
As a whole the second ridge shows a gentle forward transverse convexity. This appearance is reflected by the posterior wedging of the two small cones flanking the central pair of cones. The lingual of the two central cones has a forward bulge, while the posterior surface of the extreme lingual cone exhibits a truncated bulge where it meets the adjoining cone (Fig. 1). The buccal central cone has a small nodular projection on its posterior surface 5 mm. from the occlusal edge.

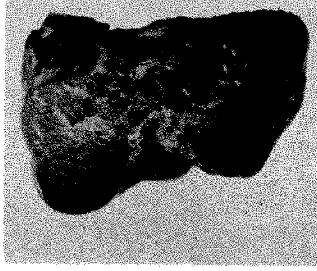
The roots have broken off, and there is no evidence of the central pits of the cones, which are completely covered by dentine on the upper (root) aspect of the specimen.

(1)

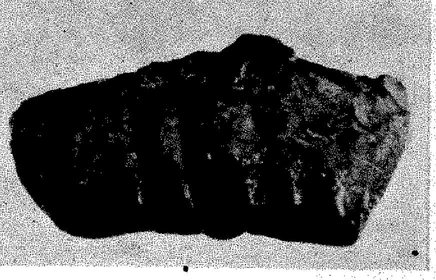


(2)





(3)



(4)

It is not possible to state definitely what the serial position of the present specimen is, but because of the stage of wear and the absence of a posterior pressure mark it is considered probable that it is a last molar, M^3 dext.

The Langebaan specimen presents a combination of mastodont and stegodont features. The low, thick-enamelled and squat lateral cones and the presence of an anterior bulge on the median cone simulating an intermediate conule indicate the mastodont affinities. The stegodont features are: the absence of a median cleft in the posterior ridges, the closure of the enamel in the base of the valley, and the arrangement of the cones in transverse rows, although the cones are not quite united into ridges to the degree seen in a true *Stegodon*. There can be no doubt as to the generic assignment of the specimen: it belongs to the genus *Stegolophodon*, which is characterized by this peculiar blending of mastodont and stegodont features[2].

The stegolophodonts represent the most primitive stegodonts. Although originally Osborn[3] included them in the Stegodontinæ, he later erected a new subfamily, the Stegolophodontinæ, for the inclusion of these forms[3]. Simpson[4] again placed them in the Stegodontinæ. In the Indian Siwaliks the single genus *Stegolophodon* ranges from the Chinji, through the Dhok Pathan and the Tatrot into the Pinjor, that is, Lower Pliocene to Lower Pleistocene. It also occurs in the Lower Pleistocene of Borneo[3]. The genus has recently been recorded by Petrocchi from Sahabi in Cyrenaica, North Africa[5,6]. He attributed the fauna in 1941 to the Miocene (?), while in 1943 it is included in the Pliocene; Hopwood and Hollyfield[7] refer the material from the Cyrenaican site to the Pliocene (?). Lower Pleistocene molars from East Africa described as *Archidiskodon planifrons nyanzae* by MacInnes[8] have been regarded by Arambourg[9] as probably belonging to *Stegolophodon*, but the specimens in question do resemble primitive archidiskodont molars so closely as to make it highly improbable for them to represent a stegolophodont.

The faunal remains obtained from nearby phosphate quarries in the Langebaan area similar to that which yielded the *Stegolophodon* represent *Rhinoceros*, *Equus*, *Sivatherium*, antelopes cf. *Oreotragus*, cf. *Damaliscus* and cf. *Redunca*, and a large buffalo, cf. *Homoioceras*. All these are essentially Pleistocene types but they are derived from limestone deposits while the *Stegolophodon* was found in the phosphate layer at a deeper level. It is probable that the limestone deposits are Upper Pleistocene whereas the phosphate layer is Middle or Lower Pleistocene. Therefore, it is most likely that the South African *Stegolophodon* is Middle Pleistocene in age.

The Langebaan stegolophodont is widely different from the bunolophodont mastodont described from the higher terrace (60–80 feet) of the Vaal River at Waldeck's Plant near Kimberley by Beck[10] and by Fraas[11]. The latter is still the only mastodont ever to have been described from South Africa.

The fossil molar fragment described in the present article provides the first evidence for the occurrence of the genus *Stegolophodon* in Southern Africa.

Because of the fragmentary nature and uncertain serial position of the Langebaan *Stegolophodon* molar, we prefer to abstain from a specific determination. Until more complete specimens have been obtained the stegolophodont of South Africa may be recorded as *Stegolophodon* sp.

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GLUCOSE CATABOLISM IN THE AMERICAN COCKROACH

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ENZYMATIC studies on the carbohydrate metabolism in insects, mostly flies and cockroaches, have revealed the operation of the Embden–Meyerhof–Parnas glycolysis[1], and a direct oxidative pathway, possibly of the pentose cycle type[2], as the major catabolic routes for the utilization of glucose in the insects. Recent tracer studies reported by Wintering-ham *et al.*[3], using acetate labelled with carbon-14, as well as other enzymatic work[4], provided evidence supporting the occurrence of the tricarboxylic acid cycle for the metabolism of acetate in flies. However, information is not yet available concerning the relative importance of these catabolic pathways of glucose in intact insects.

In this laboratory, time-course studies on the utilization by intact cockroaches (*Periplaneta americana*) of glucose specifically labelled with carbon-14 have been carried out. Respiratory carbon dioxide was collected during prescribed time intervals from the cockroaches metabolizing the labelled glucose administered by means of injection techniques[5]. Radioactive assay of the carbon dioxide samples so obtained provided confirmatory evidence for the operation of glycolysis and a direct oxidative pathway for the primary breakdown of glucose in this species.

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* On leave from Estacao Agronomica Nacional, Sacavem, Portugal; appointment supported by the International Co-operation Administration under a programme administered by the U.S. National Academy of Sciences.

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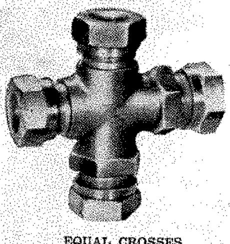

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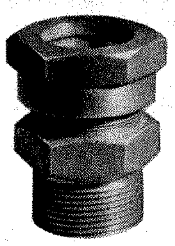

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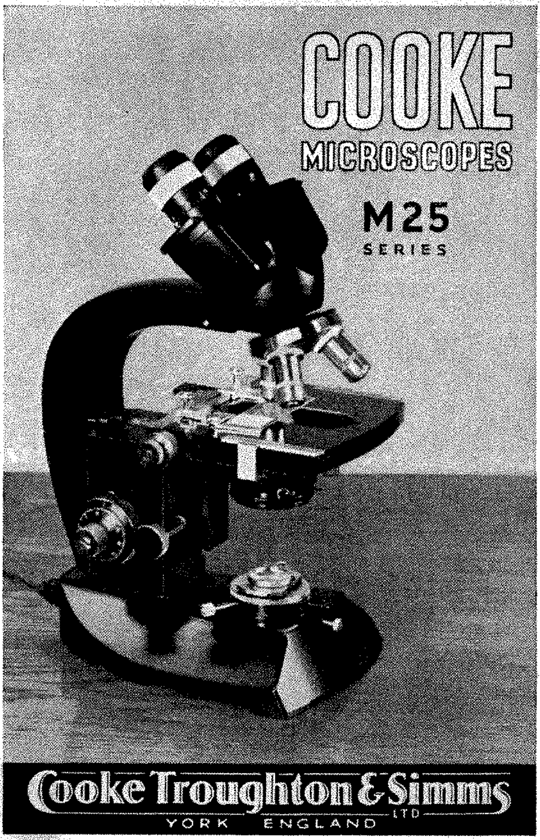

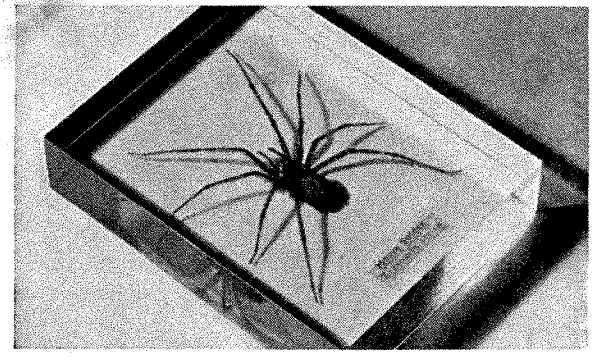

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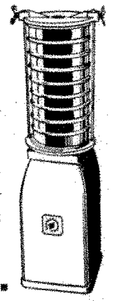

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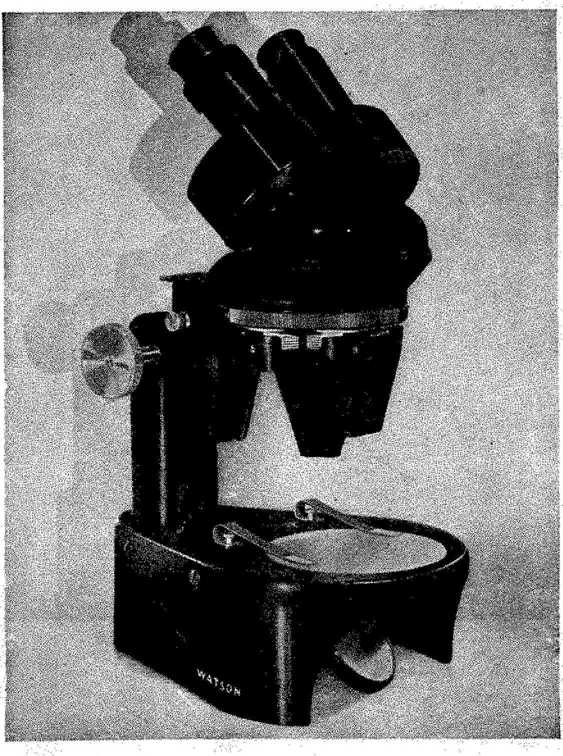

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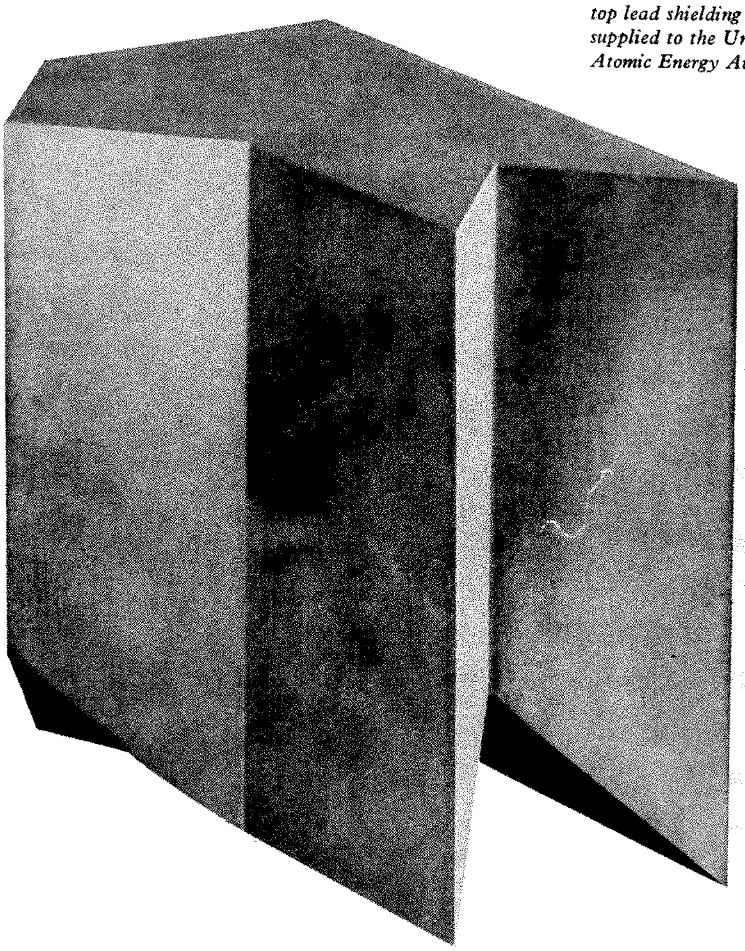

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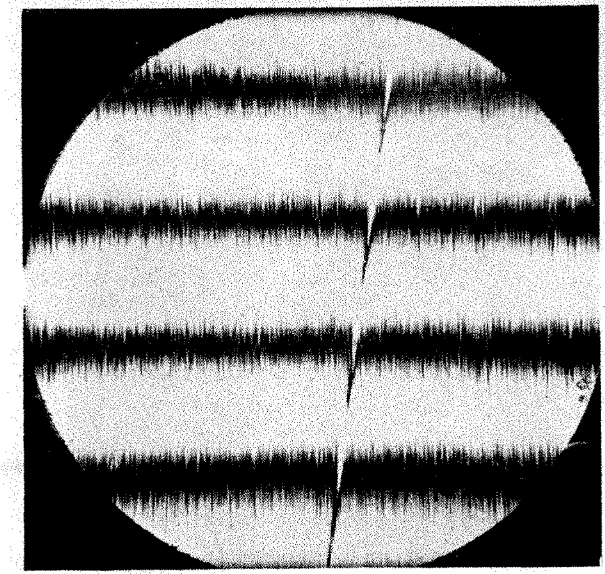

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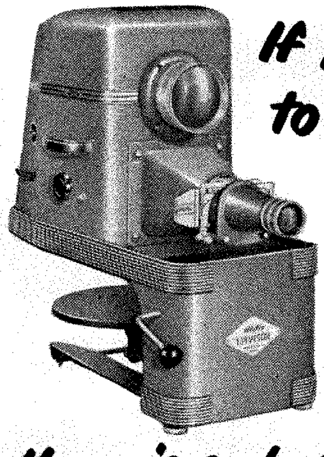

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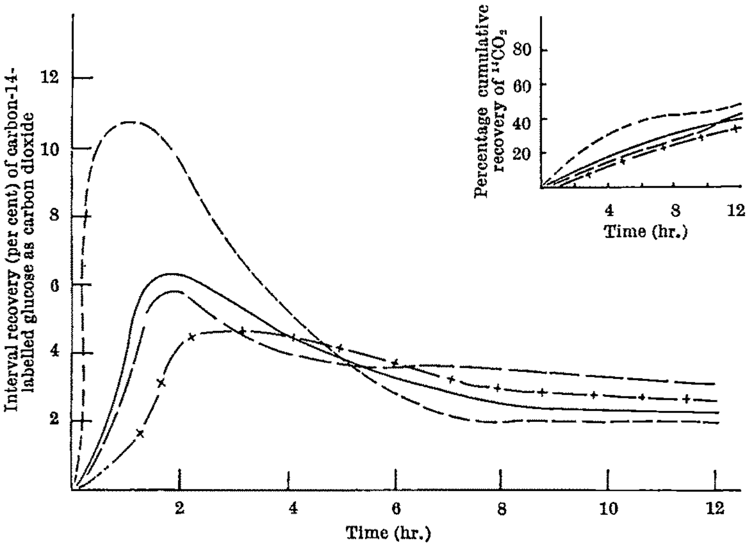

Fig. 1. Interval recovery of carbon-14 in expired carbon dioxide from *P. americana* metabolizing glucose labelled with carbon-14 : ——, glucose-1-^{14}C ; — —, glucose-2-^{14}C ; - - -, glucose-3(4)-^{14}C ; — + —, glucose-6-^{14}C

It was estimated that the latter pathway is responsible for the metabolism of only 4–9 per cent of the glucose administered in the intact cockroaches.

Essentially, the time-course experiments were carried out in a manner similar to that reported by Wang *et al.*[6] for the study of glucose metabolism in yeast. Usually 32 cockroaches, fasted for 12 hr. and divided into four groups having equal total body-weight, were used in each series of experiments. To each cockroach in the group was administered a solution of the labelled glucose, having a concentration of 250 mgm. per ml. and a specific activity of 1·8 μc./m.mole. The dose used was generally 23 μl. per gm. of cockroach. Glucoses-1,2,3(4) and 6 labelled with carbon-14 were used in each experiment (obtained through the co-operation of Dr. Isbell of the National Bureau of Standards, except in the case of glucose-3(4)-^{14}C, which was prepared in this laboratory according to the method of Wood *et al.*[7]). The cockroaches used in the present experiments were six-month adults, furnished by Dr. A. Mallis, of the Gulf Research Co. of Pittsburgh, Pennsylvania, through Prof. P. O. Ritcher, of Oregon State College. Males were used exclusively on account of their strikingly high respiratory-rate (ref. 1*c*). After the injection of the substrates, the cockroaches were kept in metabolic bottles maintained at 28° C., respiratory carbon dioxide being collected and assayed for carbon-14 by conventional techniques.

The interval radiochemical recoveries of substrate activity in the respiratory carbon dioxide from cockroaches metabolizing the specifically labelled glucose obtained in a typical experiment are given in Fig. 1. Satisfactory reproducibility was observed upon completion of scores of identical experiments. It is evident that the Embden–Meyerhof–Parnas glycolysis, in conjunction with pyruvate decarboxylation, is the major pathway for primary breakdown of glucose as indicated by the rapid recovery of the bulk of C-3(4) of glucose in carbon dioxide. The acetate produced in the foregoing processes is probably metabolized further by the conventional tricarboxylic cyclic process[3]. This is also indicated by the finding that, soon after the phase of rapid conversion of C-3(4) of glucose to carbon dioxide, C-2 of glucose began to appear in carbon dioxide at a rate constantly higher than that of C-6 until 3 hr. after the injection. The finding is understandable if one supposes that C-2 and C-6 of glucose correspond to the carboxyl and methyl carbon atoms of acetate respectively. Operation of the conventional tricarboxylic acid cyclic processes would then call for a preferential combustion of the carboxyl carbon of acetate to carbon dioxide in the early stages. That an alternate pathway is operating in the cockroaches for the primary breakdown of glucose is shown by the observed preferential recovery of C-1 of glucose in carbon dioxide as compared with that of C-6. In view of the reported activity of glucose-6-phosphate dehydrogenase and 6-phosphogluconate dehydrogenase in insects[2], it is reasonable to believe that the alternate pathway observed here in our cockroach experiments is of the phosphogluconate decarboxylation type, although the extent of the operation of the pentose cycle for the metabolism of pentoses cannot be determined in the present work.

The cumulative percentage radiochemical recoveries of substrate activity in carbon dioxide from cockroaches metabolizing glucose-1,2,3(4) and 6-^{14}C, designated respectively as G_1, G_2, $G_{3(4)}$ and G_6, are given in the insert of Fig. 1. The estimation of the individual catabolic pathways of glucose in the cockroaches were made using the method of Wang *et al.*[6]. Bearing in mind the assumptions made in the original paper[6], the extent of operation of individual catabolic pathways for the glucose administered can be expressed in the following equations :

Percentage (min.) of glucose metabolized by the phosphogluconate decarboxylation, designated G_p, is given by :

$$G_p = G'_1 - G'_6 \qquad (1)$$

where G'_1 and G'_6 represent percentage cumulative radiochemical recoveries of substrate activity in carbon dioxide from cockroaches metabolizing glucose-1-^{14}C and glucose-6-^{14}C respectively, at the time the glucose administered has been completely catabolized in the system. In the present work, the latter time was chosen as 6 hr., since at that moment the rate of recovery of C-3(4) of glucose in carbon dioxide has decreased to a much lower but steady level which reflects the exhaustion of the readily available labelled glucose in the insect.

Percentage (max.) of glucose metabolized by the glycolytic pathway, designated G_e, is given by :

$$G_e = 100 - G_p \qquad (2)$$

since it was assumed that there are only two pathways functioning in this organism.

It is understood, however, that in the foregoing equation it is assumed that the labelled glucose administered to the cockroaches was completely catabolized degradatively to its breakdown products. On the other hand, a portion of the glucose administered may have been incorporated into polysaccharides or other fractions containing glucose in its entirety. This would then necessitate an experimental determination of the amount of the labelled glucose actually engaged in catabolic functions during the experimental period before the estimation of individual pathways can be made. It appears that the fraction of carbon-14 labelled glucose actually metabolized degradatively in the insect can be estimated approximately by the following equation :

$$G_t = (G_1 - G_6) + G_{3(4)} \qquad (3)$$

where G_t is the percentage of carbon-14 labelled glucose engaged in insect catabolism up to time t; G_1, G_6, $G_{3(4)}$ are percentage radiochemical recoveries of substrate activity in carbon dioxide up to time t from cockroaches metabolizing glucose-1-^{14}C, glucose-6-^{14}C, and glucose-3(4)-^{14}C respectively.

Equation 3 is derived from the view that for each mole of glucose catabolized glycolytically 1 mole of carbon dioxide from either C-3 or C-4 of glucose will be produced, and for each mole of glucose catabolized via the direct oxidative pathway 1 mole of carbon dioxide from C-1 of glucose in excess of that from C-6 of glucose will be produced. Using the value of G_t so obtained, it is then possible to estimate the extent of operation of individual catabolic pathways of glucose as follows :

Percentage (max.) of glucose metabolized by the phosphogluconate decarboxylation, G'_p, is given by :

$$G'_p = \frac{(G_1 - G_6) \times 100}{G_t} \qquad (4)$$

and the percentage (min.) of glucose metabolized by the glycolytic pathway, G'_e, is given by :

$$G'_e = 100 - G'_p \qquad (5)$$

Using this method, it was found that in intact male adult cockroaches, glucose is catabolized by way of the direct oxidative pathway to an extent of only 4–9 per cent, and the bulk of glucose is catabolized by adult male cockroaches six months old via the Embden–Meyerhof–Parnas glycolytic pathway. The latter, in conjunction with tricarboxylic acid cyclic processes, is probably responsible for the respiratory activity and biosynthetic functions in this insect. It is quite possible that the observed small amount of activity of the direct oxidative pathway is primarily for the purpose of pentose production.

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EXPERIMENTAL ALLERGIC ENCEPHALOMYELITIS

Production of Experimental Allergic Encephalomyelitis in Guinea Pigs with Fractions isolated from Bovine Spinal Cord and Killed Tubercle Bacilli

For many years, allergic encephalomyelitis has been produced experimentally in animals by injection of a mixture containing whole brain or cord and whole killed tubercle bacilli. Many attempts have been made to fractionate the active material in nerve tissue, but tests on these fractions have always been carried out with whole killed tubercle bacilli in the adjuvant mixture. Recently, Colover and Consden[1] have reported that certain residues from tubercle bacilli possessed the same ability as the whole organism to sensitize the animal to the encephalitogenic effects of brain. Their tests were run on tubercle bacillus fractions combined with whole brain.

With Dr. Colover's co-operation, 'purified' fractions have been exchanged and combinations of cord and tubercle bacillus fractions have been tested in each laboratory. The results of our tests on these fractions are reported here.

The cord fraction which Colover tested in his laboratory was a collagen-like protein of molecular weight around 40,000, which has been found to be homogeneous by physico-chemical methods[2]. By a quantitative assay technique developed in our laboratory[3], it has been found to be two to three times as active as whole lyophilized bovine cord. Because of the high state of purity of the compound and its probable concentration in whole cord (1·6 per cent was isolated) it was concluded either that its activity was attenuated or that this compound alone could not account for the entire activity of whole lyophilized cord. Consequently, other less drastic extraction methods were investigated in an attempt to isolate a fraction with higher specific activity than the collagen-like protein.

The fraction used in our tests with Colover's tubercle bacillus fractions was a cold 5 per cent potassium chloride extract of partially defatted bovine spinal cord, which was approximately ten times as active as whole lyophilized cord when compared on a dry-weight basis, and thus five times as active as the collagen-like protein. It consisted mainly of protein with 1–2 per cent carbohydrate and no detectable

Table 1. Allergic Encephalomyelitic Activity of 'Purified' Fractions from Bovine Cord and Tubercle Bacillus

Tubercle bacillus fraction	Disease index* mean ± standard error
None	0 ± 0
0·25 mgm. whole *H37RV*†	7·9 ± 1·2
	8·4 ± 0·9
0·1 mgm. whole *H37RV*‡	7·1 ± 1·1
0·025 mgm. whole *H37RV*†	4·8 ± 1·3
0·1 mgm. Colover's 'crude' fraction	6·9 ± 1·4
0·02 mgm. Colover's 'crude' fraction	7·4 ± 1·8
0·1 mgm. Colover's 'purified' fraction (1/172)	3·2 ± 1·0
0·02 mgm. Colover's 'purified' fraction (1/172)	8·0 ± 1·0

The cord fraction was 0·02 mgm. *C–2–P* (5 per cent potassium chloride extract of partially defatted bovine spinal cord throughout).

* The disease index is a numerical evaluation of the severity of the disease reaction, based on combined clinical and histological data and the presence or absence of lipæmia. The scale is from 0 (no disease) to 10 (maximum reaction). The average of ten animals injected simultaneously is used for the disease index of a given weight of material. Maximum values for most fractions vary from 7 to 9, with a standard error of the mean of ± 1.

† Air dried. Kindly supplied by Dr. A. G. Karlson, Mayo Clinic.

‡ Lyophilized. Kindly supplied by Dr. P. Y. Paterson, New York University, and National Institute of Allergy and Infectious Diseases, Laboratory of Immunology.

lipid. More detailed information regarding the chemistry and activity of this fraction will be published elsewhere[3,4].

The results, which confirm qualitatively those reported by Colover (see following communication), are reported in Table 1. With the particular dose of the spinal cord fraction used in these tests it would appear that about half-maximal disease is produced with 0·025 mgm. whole tubercle bacilli. Small enough doses of Colover's bacillary preparations have not yet been tested to determine their 50 per cent effective doses, but it is obviously less than 0·02 mgm. It is interesting that in our tests with his 'purified' material an inhibitory effect is observed with a relatively large dose (0·1 mgm.).

Table 1

Method (see text)	Tubercle bacillus fraction	Central nervous fraction	Result*
1	2 mgm. Residue 1/172 (ref. 1)	200 mgm. whole guinea pig brain	7/11
1	2 mgm. Wax *D* Canetti†	200 mgm. whole guinea pig brain	1/6
1	2 mgm. Residue 1/172	0·8 mgm. collagen-like bovine spinal cord protein (II-*B*) (ref. 3)	5/8 (40 days)
2	0·1 mgm. Purified residue 1/172	16 mgm. guinea pig brain	5/5
2	0·1 mgm. Wax *D* Canetti	16 mgm. guinea pig brain	4/5
2	1 mgm. Wax *D* Canetti	0·2 mgm. II-*B*	5/6
2	1 mgm. Wax *D* Canetti	0·2 mgm. 5 per cent potassium chloride extract of bovine spinal cord‡	6/6

* Numerator, number of animals with experimental allergic encephalitis; denominator, number of animals in the experiment.

† This material gave different results in methods 1 and 2.

‡ Kindly prepared and supplied by Dr. E. Roboz.

As our experience accumulates in testing various brain and cord fractions, we are more and more impressed by the necessity of testing every fraction at several different dose-levels. To our knowledge, the activity of the tubercle bacillus has never been studied quantitatively. For this reason, a quantitative comparison between these two fractions and the whole tubercle bacilli cannot be made. Freund (personal communication) found that with a dose of whole brain giving maximal reaction, 0·016 mgm. killed tubercle bacillus was near the lower limit of effectiveness. Our experiments indicate a similar lower level (0·02 mgm. killed tubercle bacilli).

The experiments reported are preliminary in the sense that the fractions tested, with the exception of the collagen-like protein from bovine cord, are not pure compounds. The crucial experiment remains to be done—the production of the disease with two pure chemical compounds. The present results indicate that this goal will eventually be realized, since it has been shown that neither whole nerve tissue nor whole tubercle bacillus is an absolute requirement for the production of allergic encephalomyelitis.

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Experimental Allergic Encephalomyelitis induced with Combined 'Purified' Spinal Cord and Bacillary Fractions

IT has previously been reported by Colover and Consden[1] that residues made from heat-killed human tubercle bacilli which had been subjected to serial chemical procedures still retained the capacity to produce experimental allergic encephalomyelitis in guinea pigs when combined with homologous brain by the method (method 1, Table 1) described by Colover[2]. As a result of the kindness of Dr. Marian W. Kies, of the U.S. National Institute of Mental Health, a sample of 'collagen-like protein II-*B*'[3] prepared from bovine spinal cord by Dr. E. Roboz was made available for trial with this bacillary residue (1/172)[1]. An emulsion was made so that each ml. contained: 0·5 mgm. bacillary residue 1/172; 0·4 ml. 'Bayol *F*'; 0·2 ml. 'Falba'; 0·4 ml. normal saline; 0·2 mgm. collagen-like protein II-*B*. This latter fraction was used as a substitute for the 50 mgm. of heated brain emulsion previously used[1]. Eight guinea pigs were injected with 1 ml. of emulsion at weekly intervals between the scapulæ intramuscularly, each animal receiving four injections. Three became severely paralysed and died just before the thirtieth day; the remainder were killed on the fortieth day. On histological examination five animals showed the typical lesions of experimental allergic encephalomyelitis, and another animal showed a large intradural granuloma. The extent of the lesions was less than when 50 mgm. of heated brain emulsion per ml. were used as the brain factor. Six control animals were similarly treated except for the omission of the bacillary factor from the injected material. Three were killed at 30 days and three at 40 days. None showed neurological signs, but one showed an isolated focus of microglial reaction in one cerebral hemisphere histologically.

Kies, Alvord and Roboz (see previous communication), using a different technique, mixed a sample of the same purified bacillary residue prepared by Colover and Consden with another bovine spinal cord protein prepared by extracting the cord with 5 per cent potassium chloride after preliminary defatting, and have found this mixture was active in producing experimental allergic encephalomyelitis in guinea pigs.

Previous attempts by Colover and Consden[1], Colover[2,4], were negative when various wax fractions of tubercle bacilli were combined with homologous whole brain. Positive results with wax fractions had been obtained[5,6], and in view of this a further trial was made with wax *D* Canetti prepared by Dr. J. Asselineau and kindly supplied by Dr. E. Lederer, containing similar components to those present in the residue 1/172 (Lederer, E., personal communication). The method of injection (method 2, Table 1) differed from that described above (method 1) in that single injections of 0·2 ml. of the following emulsions were injected into the dorsum of the hind foot of guinea pigs: 1 or 0·1 mgm. bacillary fraction; 0·085 ml. 'Bayol *F*'; 0·015 mgm. 'Arlacel *A*'; 0·1 ml. saline; 16 mgm. of whole guinea pig brain or 0·2 mgm. bovine spinal cord fraction.

Table 1 shows that by this method homologous whole brain and both bovine spinal cord fractions were effective with wax *D* Canetti.

The results reported here and by Kies, Roboz and Alvord in the previous communication confirm that experimental allergic encephalomyelitis can be produced in guinea pigs by emulsions containing only relatively small fractions of acid-fast bacilli and central nervous tissue, and show that either of two constituents of tubercle bacilli (residue 1/172 and wax *D* Canetti) mixed with either of two bovine spinal cord protein fractions can be effective.

I would like to thank the Medical Research Council for a grant towards this work.

Note added in proof. Since the submission of this paper it has been found that 1 mgm. of chromatographically pure wax *D* Canetti (E. Lederer), which is a pure compound, combined with fraction II-*B* produces a high incidence of experimental allergic encephalitis in guinea pigs.

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SYNTHETIC POLYPEPTIDE SUBSTITUTES FOR GELATIN IN PHOTOGRAPHIC EMULSIONS AND OBSERVATIONS ON GELATION

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THE synthesis of water-soluble ampholytic polypeptides has been undertaken with the view of simulating those properties of gelatin which are involved in the preparation of photographic emulsions. Two attributes will be discussed here. The first, of specialized interest, is the ability to promote the growth of flat, well-shaped silver halide grains during the process of physical ripening. Many of the colloids which have been proposed as substitutes for gelatin, for example polyvinyl alcohol, are not able to do this. It seemed at one time that a polypeptide structure was obligatory; but recently, it has been found that certain polyethylene oxides are effective[1]. It is now shown that the required kind of grain-growth can be achieved with synthetic polypeptides. The work also permits some observations on the other important property of gelatin, one which is of wider interest, namely, gelation. The two attributes under consideration, control of grain-growth and gelation, are not necessarily so diverse in origin as would at first appear, because the former probably relies partly on those intermolecular links which are formed, to a much greater extent, in a gel.

Ampholytic polypeptides have been synthesized by a method, now well known, in the following two stages. (1) Co-polymerization of Leuchs's anhydrides in dioxan with ammonia as catalyst; the main components were the anhydrides of γ-methyl glutamate and ε-N-carbobenzyloxylysine. (2) Removal of side-chain protective groups to give water-soluble polypeptides containing glutamic acid and lysine.

Polypeptides which would control grain-growth in the manner required resulted when highly purified intermediates and controlled amounts of initiator were used at the polymerization stage. Only in this way may compounds of high molecular weight be obtained, according to Blout *et al.*[2]. The observations of the latter in respect of the polymerization of γ-methyl-L-glutamate anhydride have been confirmed. When prepared by the method of Hanby *et al.*[3], γ-methyl glutamate itself was found to contain persistent traces of glutamic acid which could not be removed except by an anion-exchanger. The corresponding Leuchs's anhydride, after several recrystallizations, had m.p. 104° as against the reported values of 96–97°[2] and 99–100°[3]. Polymethyl glutamate prepared from this had η_i (in dichloracetic acid) = 1·32. Referred to data of Doty *et al.*[4] on the benzyl ester, this represents a molecular weight of about 200,000. Previous samples of the polypeptide from not specially purified anhydride had $\eta_i \sim 0{\cdot}1$. For the other main component, DL-lysine was used, as it was not found possible to purify L-lysine (natural origin) satisfactorily. The pure ε-N-carbobenzyloxylysine anhydride had m.p. 110°.

Co-polymers have been prepared from the above two anhydrides in various proportions, alone and admixed with proportions of another neutral amino-acid anhydride, namely, glycine, phenylalanine, cystine, proline or sarcosine. Elementary analyses of the products were in good agreement with expectation based on a long chain (so that end groups can be ignored). Discrepancies previously noted[5] may perhaps be ascribed to chain-branching and termination reactions, due to an excess of initiators in the intermediates.

Water-soluble polypeptides (stage *b*), co-polymers of glutamic acid and lysine alone or with the other amino-acids mentioned, were prepared by mild treatment of the above with hydrogen bromide in acetic acid, followed by precipitation with ether and dissolution in weak alkali. The last operation was facilitated by the presence of proline or sarcosine, presumably because of the reduced tendency to form intermolecular linkages on the peptide nitrogens which, with these two amino-acids, do not have a

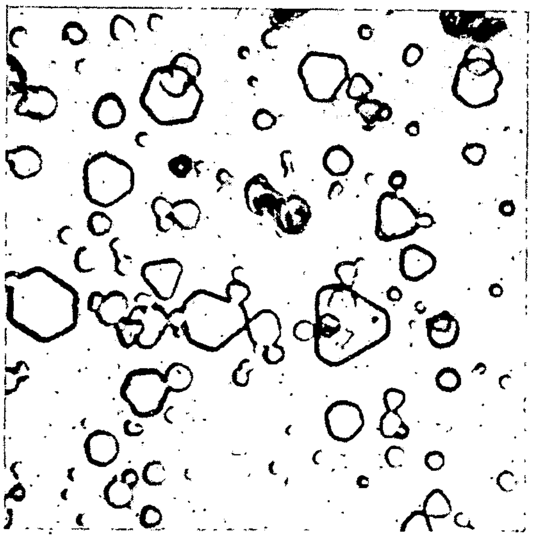

Fig. 1. Photomicrograph of silver iodobromide grains grown in the presence of a polypeptide of expected formula $Glu_4Lys_3Sar_3Cys_{0.1}$. No other colloid was present at any time during the preparation of the emulsion or slide. (× 2,500)

hydrogen substituent. This observation was useful when dissolving polypeptides containing cystine, the disulphide group of which is very sensitive to alkali. The products were isolated from the neutralized aqueous solutions by precipitation with alcohol and, in this respect, resembled gelatin. They are in general freely soluble in water at all pH-levels. Although polyglutamic acid itself is insoluble in water, a minor amount (20 per cent) of lysine in the co-polymer is sufficient to prevent precipitation. Glutamic acid is less effective at the other end of the scale and co-polymers with relatively large proportions of lysine ($>$ 80 per cent) are insoluble at high pH.

Flat, well-shaped silver halide grains have been grown in many of the polypeptides prepared, including those containing only glutamic acid and lysine. The composition is not critical, nor does it need to be complex. In support of this, it may be mentioned that grain-growth has also been produced using the soluble form of silk fibroin[6], a protein with a simpler amino-acid structure than gelatin. The important point is that the required grain growth was only achieved when pure intermediates had been used. From the above data on polymethylglutamate it is believed (though not proved) that the result is indicative of high molecular weights. An example of silver halide grains ripened in the presence of one of the water-soluble polypeptides is shown in Fig. 1.

None of the polypeptide solutions at any pH or concentration-level gave true gels. The nearest approach was with compounds containing large amounts of lysine, which gave gelatinous precipitates at high pH. Some observations have been made relative to the hypothesis of Grabar *et al.*[7] that gelation depends on the presence of arginine units in gelatin. The hypothesis rests on the fact that the power to gel is destroyed by hypobromite, a reagent known to disrupt guanidino groups. The matter has been further studied by Davis[8], and Janus[9] has found that guanidation of gelatin increases gel rigidity. The chemical effect of guanidating gelatin has been analysed by Eastoe *et al.*[10].

Polypeptides containing glutamic acid with ornithine or lysine have been treated with O-methylisourea at pH 10. This reagent converts ornithine to arginine and lysine to homoarginine. (Polyarginine has previously been prepared along these lines by Katchalski *et al.*[11].) The products were again isolated by alcohol precipitation of the neutralized solutions. The completeness of the guanidation could be checked conveniently by paper electrophoresis of hydrolysates. In phthalate buffer at pH 6, the mobilities towards the cathode of arginine and homoarginine are the same, as are those of ornithine and lysine; the ratio of the mobility of the first pair to that of the second is 0·85. Ornithine may thus be separated from arginine or lysine from homoarginine in a few hours. Glutamic acid moves away in the direction of the anode.

Guanidation of the polypeptides did not introduce the ability to gel. (The properties as regards control of grain-growth were also unaffected.) The result suggests that the arginine unit of gelatin does not play the decisive part in gelation, envisaged by Grabar *et al.* It seems likely that the reagent used by the latter will destroy or brominate important groups other than guanidino; for example, peptide. The effect of blocking the nitrogen of the peptide groups is seen in polypeptides containing sarcosine, which are not only easier to convert to the soluble form (cf. above) but give much less viscous aqueous solutions, implying reduced molecular interaction.

Just as this account had been completed, a communication appeared emphasizing the importance of peptide groups: in it, Bello *et al.*[12] show that gelation is inhibited by forming copper-peptide complexes.

Some success having been achieved in the aim of simulating the properties of gelatin, as regards control of grain-growth, with essentially simpler synthetic polypeptides, it is proposed to continue the search for the gelling factor(s). Clearly, something other than a polypeptide backbone is required in the molecule. In view of its unique occurrence in collagenous proteins, hydroxyproline (not yet incorporated in the present polypeptides) is of obvious interest. A more remote possibility is that the polysaccharide 'impurity' of gelatin[13] is important. If a particular sequence of amino-acid residues is involved, the present synthetic method is unlikely to be useful. It has long been known that side-chain polar groups do not play an important part in gelation, since the latter is not dependent upon pH[14]. The main function of these groups in the polypeptides is to confer solubility in water.

Thanks are due to Messrs. D. J. Farmery and J. P. Johnson for technical assistance and to the Directors of Ilford, Ltd., for permission to publish this communication.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Lung Cancer and Cigarettes?

THE association observable between the practice of cigarette smoking and the incidence of cancer of the lung, to which attention has been actively, or even vehemently, directed by the Medical Research Council Statistical Unit, has been interpreted, by that Unit, almost as though it demonstrated a causal connexion between these variables.

The suggestion[1], among others that might be made on the present evidence, that without any direct causation being involved, both characteristics might be largely influenced by a common cause, in this case the individual genotype, was indeed rejected with some contempt by one writer[2], although I believe that no one doubts the importance of the genotype in predisposing to cancers of all types.

It seemed to me that although the importance of this factor had been overlooked by the Unit in question, it was well within the capacity of human genetics, in its current state, to examine whether the smoking classes to which human beings assign themselves, such as non-smokers, cigarette smokers, pipe smokers, cigar smokers, etc., were in fact genotypically differentiated, to a demonstrable extent, or whether, on the contrary, they appeared to be genotypically homogeneous, for only on the latter view could causation, either of the disease by the influence of the products of combustion or of the smoking habit by the subconscious irritation of the postulated pre-cancerous condition, be confidently inferred from the association observed.

The method of inquiry by which such differentiation can be recognized is the same as that by which the congenital factor has been demonstrated for several types of disease[3], namely, the comparison of the similarities between monozygotic (one-egg) and dizygotic (two-egg) twins respectively; for any recognizably greater resemblance of the former may be confidently ascribed to the identity of the genotypes in these cases.

I owe to the generous co-operation of Prof. F. von Verschuer and of the Institute of Human Genetics of the University of Münster the results of an inquiry into the smoking habits of adult male twin pairs on their lists.

The data so far assembled relate to 51 monozygotic and 31 dizygotic pairs, from Tübingen, Frankfurt and Berlin. Of the first, thirty-three pairs are wholly alike qualitatively, namely, nine pairs both non-smokers, twenty-two pairs both cigarette smokers and two pairs both cigar smokers. Six pairs, though closely alike, show some differences in the record, as in a pair of whom one smokes cigars only, whereas the other smokes cigars and sometimes a pipe. Twelve pairs, less than one-quarter of the whole, show distinct differences, such as a cigarette smoker and a non-smoker, or a cigar smoker and a cigarette smoker.

By contrast, of the dizygotic pairs only eleven can be classed as wholly alike, while sixteen out of thirty-one are distinctly different, this being 51 per cent against 24 per cent among the monozygotics.

The data can be rearranged in several ways according to the extent to which attention is given to minor variations in the smoking habit. In all cases, however, the monozygotic twins show closer similarity and fewer divergencies than the dizygotic.

There can therefore be little doubt that the genotype exercises a considerable influence on smoking, and on the particular habit of smoking adopted, and that a study of twins on a comparatively small scale is competent to demonstrate the rather considerable differences which must exist between the different groups who classify themselves as non-smokers, or the different classes of smokers. Such genotypically different groups would be expected to differ in cancer incidence; and their existence helps to explain such oddities as that pipe and cigar smokers should show much less lung cancer than cigarette smokers, while among the latter, the practice of inhaling is associated with less rather than with more cancer of the lung.

Dr. Bradford Hill, while admitting that the evidence of association found by his Unit did not amount to proof of causation, has emphasized that he does not know what else it can be due to. The facts here reported do show, however, that the choice is not so narrow as has been thought.

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Measurement of Toughness in Cold-stored Fish

LUIJPEN recently noticed[1] that the proportion of fish muscle protein that would dissolve in 5 per cent sodium chloride solution was not correlated with the development of toughness during cold-storage at or below $-20°$ C. The discovery was of great significance to the study of cold-storage phenomena, because it implied that the soluble protein nitrogen (usually expressed as a percentage of the total protein nitrogen) could not now be used as an objective standard for the quality of cold-stored fish. This was contrary to former belief.

It seems likely, therefore, that future investigations of freezing and cold-storage of fish will require the direct estimation of toughness as a measure of quality change. A satisfactory method for measuring toughness does not, however, exist at present. Assessment by a taste panel is time-consuming and inaccurate, and can only deal with a few samples at a time. Machines such as penetrometers, various types of shear apparatus, etc., which successfully estimate the toughness of beef muscle, are not as a rule adaptable to fish because the fibres in the latter case are extremely short and interspersed with sheets of connective tissue (myocommata) which are tougher than the muscle itself.

The following method, which requires only a small piece of fish muscle, was therefore devised. It has so far been tried out only on uncooked cod (*Gadus callarias* L.).

A handle was made to hold two Swann–Morton No. 24 scalpel blades 3 mm. apart and parallel. By means of a gentle sawing action, the blades were sunk into a wide myotome (muscle segment) on the 'bone' side of the fillet, at right angles to the long

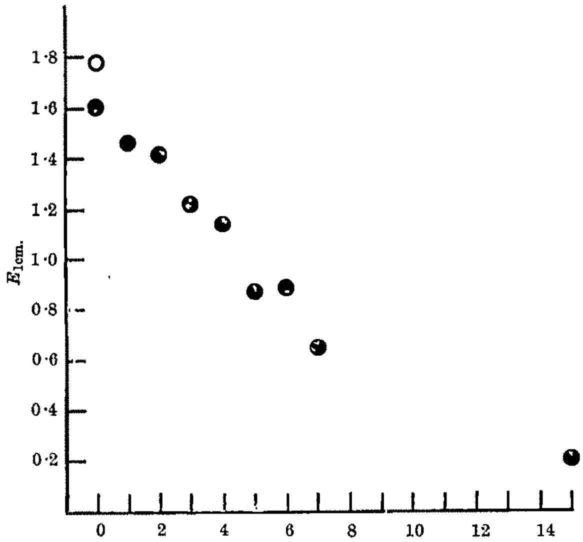

Fig. 1. Optical density of brei obtained by homogenizing muscle from cod fillets, frozen in 12 hr. and stored, wrapped, at −14° C. for different times. Each point is the average for thirty fillets determined in duplicate. ○, Fresh muscle before freezing; ●, frozen and thawed

axis, in the block of muscle lying immediately dorsal to the lateral line. The 'double scalpel' was then withdrawn with a slight twisting movement, so that a piece of muscle containing fibres of uniform length became detached from the fish and could be poked out from between the blades. It was freed from any traces of connective tissue, and two aliquots, each of 200 ± 5 mgm., were weighed out on a torsion balance.

20 ml. of approximately 1 per cent formaldehyde solution were used to fill the metal cup of a Marsh–Snow homogenizer[2] which had been fitted with a baffle plate just above the paddle blade to prevent frothing. The weighed sample was added to this, and the homogenizer run for 20 sec. at about 2,200 r.p.m. It was important not to put the tissue in before the formaldehyde. The resulting homogenate was poured with minimum delay into a ½-cm. optical cell, and the optical density read immediately with a photometer. The wave-length of the incident light was selected so that the readings were conveniently placed on the scale of the photometer. In the present experiments a 430 mμ filter with a Hilger 'Biochem' absorptiometer was satisfactory. It was important to avoid any trace of frothing, and in this connexion the formaldehyde was kept below 20° C., being most satisfactory when cooled below 10° C. before the start of the experiment.

It was observed that the fibres from fresh fish muscle were completely broken up by this treatment, making an optically dense 'soup'. Frozen fish showed an increasing proportion of intact fibres in the brei as the storage time increased, until eventually only intact fibres were found, suspended in clear liquid which let through much more light. The optical density in the intermediate stages decreased regularly according to the number of intact fibres present.

Microscopic examination of breis from fish of intermediate toughness showed that, while a few fibres appeared to have been split longitudinally[3], the majority were either completely dispersed as fine fibrils or completely intact. This seems to show that 'toughness' is related to the cell envelope, destruction of which releases all the fibrils, which it would not do if the cells as a whole were becoming tougher.

Fig. 1 shows the changes in texture of frozen cod fillets, as measured by the new method, that occurred during cold storage at −14° C. It will be seen that freezing itself increased toughness and that the fish then became progressively tougher during subsequent storage. The immediate effect of freezing can usually be detected qualitatively by a taste panel, but as a rule it is not possible to measure subsequent changes in texture with any precision by this means.

We would thus seem to have a satisfactory method for assessing the texture of frozen fish. There are several possible factors such as the effects of the size of the fish and the treatment before freezing, manner of freezing, etc., which have not yet been examined. As these would be genuine changes in texture, however, they would not affect the validity of the results, but only their interpretation.

It is hoped to publish a full report of these investigations elsewhere.

I am indebted to Mr. Harry Bruce, who made the homogenizer and the special scalpel, and to Miss Eleanor Brown for technical assistance. The work described is part of the programme of the Food Investigation Organization of the Department of Scientific and Industrial Research.

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May 15.

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Hexokinase Activity in Cell-free Extracts of *Leishmania donovani*

Leishmania donovani, the protozoan organism causing visceral leishmaniasis, is known to utilize glucose and other carbohydrate substrates for its continued metabolic activity. The evidence available, however, does not show whether phosphorylation plays a direct or an indirect part in the utilization of carbohydrates by this organism. During an investigation into the mechanism of utilization of various carbohydrates by *L. donovani*, strong hexokinase activity has been detected in the cell-free extracts of this organism. *L. donovani*, strain 81, cultured on Ray's medium[1] at 24° C. and recycled every three weeks from the N.N.N. medium, was used in this study. After growth for three days on Ray's medium, the organism was scraped from the surface of the agar, washed once with ice-cold isotonic saline and ground with glass powder, with gradual additions of ice-cold isotonic saline. Isotonic potassium chloride in place of sodium chloride was found to be equally satisfactory. The crushed suspension was centrifuged at 3,000 r.p.m. for 5 min. and the supernatant was used as crude enzyme extract.

Hexokinase activity has been followed by three different methods: (*a*) the manometric method of Colowick and Kalckar[2], (*b*) measurement of disappearance of free sugar by Nelson's method[3] and (*c*) the phosphorus-balance method, measuring the utilization of acid-labile phosphate and the concomitant formation of esterified phosphate.

Standard conditions for the assay of the hexokinase activity were as follows: 3·0 ml. of the complete reaction mixture contained 10 μmoles of substrate, 20 μmoles of the sodium salt of adenosine triphosphate, 10 μmoles of magnesium sulphate, 180 μmoles of sodium fluoride, 30 μmoles of sodium bicarbonate (*p*H 7·4), 1 cm.^{3} of enzyme extract containing 0·3–0·35 mgm. total nitrogen. Incubations were carried out in conventional Warburg manometric vessels at 37° C. in an atmosphere of 95 per cent nitrogen and 5 per cent carbon dioxide.

The rate at which carbon dioxide was evolved from the bicarbonate buffer, after due corrections for any adenosine triphosphatase and other non-specific activities destroying adenosine triphosphate, gave an approximate measure of the hexokinase activity. For measuring the amount of sugar utilized due to the hexokinase activity, aliquots of the samples at different time intervals were treated with barium hydroxide and zinc sulphate, using Somogyi's method[4], and the free reducing sugars were analysed by Nelson's method[3]. A control experiment was carried out without adenosine triphosphate and the activity was expressed on the basis of net difference in free glucose over the control. Acid-labile phosphate was determined by estimating the inorganic phosphate released after heating an aliquot with 1 *N* hydrochloric acid at 100° C. for 7 min. Esterified phosphate was estimated from the difference in the amount of adenosine triphosphate used up and the inorganic phosphorus liberated during incubation. Phosphorus estimations were done by Fiske and Subbarow's method[5]. All the sugars used in this study were of *dextro*-varieties.

Typical rates of output of carbon dioxide in the presence of different sugars are shown in Table 1. In the case of *d*-glucosamine, no correction was made, however, for its acid-binding power in the present experimental conditions. From the relative phosphorylation-rates given in Table 1, it will be noted that the hexokinase activity in the cell-free extracts of this protozoal organism is very marked towards glucose, fructose, mannose and *d*-glucosamine, whereas with galactose, glycerol and ribose the activity seems to be a little weaker. The presence of such an active glucosamine-phosphorylating enzyme suggests that this amino-sugar may play some important part in the metabolism of *L. donovani*. In order to characterize the substrate specificity of this hexokinase, some preliminary experiments were carried out, using mixtures of hexoses and *d*-glucosamine, on the rate of phosphorylation. The results indicate that for glucose, fructose, mannose, galactose and *d*-glucosamine a single hexokinase enzyme may be involved, since there is a mutual inhibitory effect on the rate of glucose phosphorylation in presence of either fructose, galactose, mannose or *d*-glucosamine. This inhibition may apparently be due to competition of all the substrates for the common enzyme involved. In this respect the protozoal enzyme has some similarity with yeast and brain hexokinases[6].

Table 1. PHOSPHORYLATION OF DIFFERENT SUGARS BY CELL-FREE EXTRACTS OF *L. donovani*

Substrate used (0·01 *M*)	Carbon dioxide liberated (μl.) at different time intervals (min.)					
	5	10	15	20	25	30
Glucose	20	38	53	63	70	75
Fructose	21	40	54	63	71	78
Mannose	16	30	43	51	58	64
Galactose	8	14	18	22	25	27
d-Glucosamine	16	32	47	59	69	74
Glycerol	5	3	1	—	—	—
Ribose	4	2	1	—	—	—

Table 2. PHOSPHORYLATION OF GLUCOSE BY EXTRACTS OF *L. donovani*

Exp. No.	Glucose disappearance (μmoles)	Carbon dioxide evolved (μmoles)	Adenosine triphosphate used (μmoles)	Esterified phosphate formed (μmoles)
1	2·9	3·0	14·0	2·4
2	3·0	3·5	13·0	2·8
3	3·2	3·5	12·8	3·0

The results in Table 2, illustrating three typical experiments carried out for half an hour under standard experimental conditions, suggest that there is a fairly close stoichiometric balance between the amount of glucose utilized and the amount of esterified phosphate formed, most of which was found in combination with fructose.

A number of substances, such as *p*-chloromercuric benzoate, αα′-dipyridyl, iodoacetate (used at 10^{-4} *M* concentrations), were found to have a very small inhibitory effect on the activity of this enzyme. The activity of the enzyme extract was not improved by additions of cysteine or glutathione. These findings indicate that the hexokinase enzyme of *L. donovani* is not markedly dependent upon functional —SH groups for its activity.

Details regarding the substrate specificities, substrate affinities, *p*H optima and co-factor requirements of this enzyme will be published elsewhere.

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Effect of Larval Brain on the Imaginal Differentiation in the Silkworm

I HAVE shown earlier[1,2] that, in *Bombyx mori*, pupal brain has a function which brings about imaginal differentiation, probably by affecting the prothoracic gland in the pupa, and that the mode of action by which the prothoracic gland is influenced is hormonal in nature. Kobayashi and Kirimura[3] attempted to extract the hormone and succeeded in obtaining an oily substance which is effective in bringing about imaginal differentiation in the 'Dauer-pupæ' from the extract of the pupal brain.

It has not yet been established, however, whether the larval brain has the same function in imaginal differentiation as the pupal brain. Accordingly, I have investigated this problem by implanting larval brain into the head of 'Dauer-pupa' of *Bombyx mori.*

The larvæ of the F_1 hybrid between two races, *J*115 and *C*108, were used as donors of brain and the 'Dauer-pupæ' of the hybrid between two races, *J*122 and *C*115, were used as recipients.

Brains to be tested were removed from the 5th instar larvæ on the fourth day after the fourth moult.

Table 1. EFFECT OF IMPLANTATION OF A FRESH LARVAL BRAIN INTO EACH 'DAUER-PUPA' AT 25° C.

No. of 'Dauer-pupae' used as recipient	No. of dead individuals	No. of moths emerged	Days from implantation to emergence
15 (♀)	1	14	18–25*

* Mean time from implantation to emergence, 20 days.

A fresh brain was implanted into the head of each 'Dauer-pupa', the 'Dauer-pupæ' having been kept at 25° C. for 30 days after being deprived of their brains immediately following pupation. After the implantation, the pupæ were kept at 25° C.

As shown in Table 1, 14 out of 15 pupæ operated became moths during the period from the eighteenth to the twenty-fifth day after the implantation and one died after five days. No imaginal differentiation was observed in 15 'Dauer-pupæ', in which no brain had been implanted although they were kept at 25° C. for 100 days after pupation.

It is concluded that the larval brain is as effective as the pupal brain in the imaginal differentiation of 'Dauer-pupa'.

In silkworm pupa, the brain hormone is elaborated in the neurosecretory cells of the brain and is released into the blood stream[2]. On the other hand, in the 4th and 5th larval stage the neurosecretory materials elaborated in the neurosecretory cells of the brain were released through two paths, one from the cell to the nervi corporis cardiaci through the axon of the *A*-cell, and the other from the cell to the blood stream through the cortex of the brain[2]. It is highly probable, therefore, that the secretory material released through the latter path is the brain hormone concerned with imaginal differentiation.

Thus it appears that even in the larval stage the secretion of the brain affects the prothoracic gland in *Bombyx mori*.

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A Correlation between the Compositions of Deoxyribonucleic and Ribonucleic Acids

WE have shown that the composition of the ribonucleic acid of bacterial cells does not depend upon the very considerable changes in composition of deoxyribonucleic acid found when profound reorganizations of the hereditary nature of intestinal bacteria occur[1,2]. The composition of deoxyribonucleic acid in different bacterial species belonging to various systematic groups was shown to vary widely (from the extreme *AT*-type to the highest *GC*-type); whereas that of ribonucleic acid from these species was shown to vary slightly, small differences being noted only between very diverse species[3,4]. Thus the greater part of the ribonucleic acid of the cell appeared to be independent of the deoxyribonucleic acid.

However, a certain correlation was found to exist. This correlation is expressed in a tendency towards an increase in the ratio $\frac{G+C}{A+U}$ in ribonucleic acid when passing from the species with the smaller $\frac{G+C}{A+T}$ ratio in their deoxyribonucleic acid to those with greater values of this ratio[4].

We have studied the composition of the two nucleic acids applying methods[1] based on the mild alkali hydrolysis of the total bacterial mass (after removing acid-soluble substances) by means of a modified form of the method of Schmidt and Thannhauser. The composition of the ribonucleic acid was determined by paper chromatography of nucleotides; the composition of the deoxyribonucleic acid was determined by paper chromatography of bases. The eluates of spots were examined in the ultra-violet with a quartz spectrophotometer. Each result represents the mean of at least four single determinations in each of two parallel hydrolysates for each culture. The mean error of the mean values for nucleotides and bases presented in Tables 1 and 2 was not greater than 2 per cent. In both tables the species

Table 1. COMPOSITION OF BACTERIAL DEOXYRIBONUCLEIC ACIDS

Species	Bases (moles per cent)				$\frac{Pu}{Py}$	$\frac{G+T}{A+C}$	$\frac{G+C}{A+T}$
	G	*A*	*C*	*T*			
Clostridium perfringens	15·8	34·1	15·1	35·0	1·00	1·03	0·45
Staphylococcus pyogenes aureus	17·3	32·3	17·4	33·0	0·98	1·01	0·53
Pasteurella tularensis	17·6	32·4	17·1	32·9	1·00	1·02	0·53
Proteus vulgaris	19·8	30·1	20·7	29·4	1·00	0·97	0·68
Escherichia coli	26·0	23·9	26·2	23·9	1·00	1·00	1·09
Proteus morganii	26·3	23·7	26·7	23·3	1·00	0·98	1·13
Shigella dysenteriae	26·7	23·5	26·7	23·1	1·01	0·99	1·15
Salmonella typhosa	26·7	23·5	26·4	23·4	1·01	1·00	1·13
Salmonella typhimurium	27·1	22·9	27·0	23·0	1·00	1·00	1·18
Erwinia carotovora	27·1	23·3	26·9	22·7	1·02	0·99	1·17
Corynebacterium diphtheriae	27·2	22·5	27·3	23·0	0·99	1·01	1·20
Aerobacter aerogenes	28·8	21·3	28·0	21·9	1·00	1·03	1·31
Mycobacterium vadosum Kras.	29·2	20·7	28·5	21·6	1·00	1·03	1·37
Brucella abortus	29·0	21·0	28·9	21·1	1·00	1·00	1·37
Alcaligenes faecalis	33·9	16·5	32·8	16·8	0·98	1·03	2·00
Pseudomonas aeruginosa	33·0	16·8	34·0	16·2	0·99	0·97	2·03
Mycobacterium tuberculosis BCG	34·2	16·5	33·3	16·0	1·03	1·01	2·08
Sarcina lutea	36·4	13·6	35·6	14·4	1·00	1·03	2·57
Streptomyces griseus	36·1	13·4	37·1	13·4	0·98	0·98	2·73

Abbreviations: *G*, guanine; *A*, adenine; *C*, cytosine; *T*, thymine; *Pu*, purine bases; *Py*, pyrimidine bases.

Table 2. COMPOSITION OF BACTERIAL RIBONUCLEIC ACIDS

Species	Bases (moles per cent)				$\frac{Pu}{Py}$	$\frac{G+U}{A+C}$	$\frac{G+C}{A+U}$
	G	*A*	*C*	*U*			
Clostridium perfringens	29·5	28·1	22·0	20·4	1·36	1·00	1·06
Staphylococcus pyogenes aureus	28·7	26·9	22·4	22·0	1·25	1·03	1·05
Pasteurella tularensis	29·8	27·3	21·0	21·9	1·33	1·07	1·03
Proteus vulgaris	31·0	26·3	24·0	18·7	1·34	0·99	1·22
Escherichia coli	30·7	26·0	24·1	19·2	1·31	1·00	1·21
Proteus morganii	31·1	26·0	23·7	19·2	1·31	1·01	1·21
Shigella dysenteriae	30·4	25·9	24·4	19·3	1·29	0·99	1·21
Salmonella typhosa	30·8	26·1	24·0	19·1	1·32	1·00	1·21
Salmonella typhimurium	31·0	26·1	23·8	19·1	1·33	1·00	1·21
Erwinia carotovora	29·5	26·5	23·7	20·3	1·27	0·99	1·14
Corynebacterium diphtheriae	31·6	23·1	23·8	21·5	1·21	1·13	1·24
Aerobacter aerogenes	30·3	26·0	24·1	19·6	1·29	1·00	1·19
Mycobacterium vadosum Kras.	31·7	23·8	23·5	21·0	1·25	1·12	1·23
Brucella abortus	30·2	25·4	24·9	19·5	1·26	0·99	1·23
Alcaligenes faecalis	30·9	25·7	24·1	19·3	1·31	1·01	1·22
Pseudomonas aeruginosa	31·6	25·1	23·8	19·5	1·31	1·05	1·24
Mycobacterium tuberculosis BCG	33·0	22·6	26·1	18·3	1·25	1·05	1·45
Sarcina lutea	32·7	23·2	24·2	19·9	1·27	1·11	1·32
Streptomyces griseus	31·1	23·8	25·2	19·9	1·22	1·04	1·29

Abbreviations: *G*, guanylic acid; *A*, adenylic acid; *C*, cytidylic acid; *U*, uridylic acid; *Pu*, purine nucleotides; *Py*, pyrimidine nucleotides.

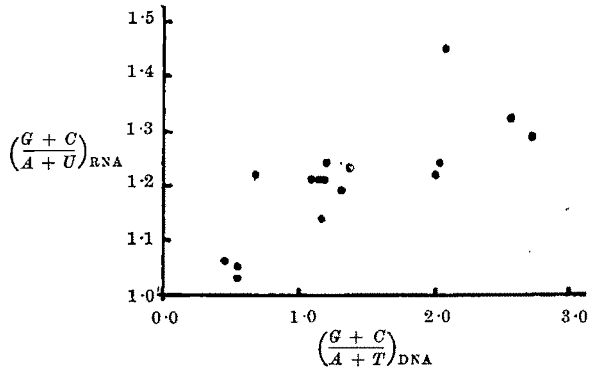

Fig. 1

are arranged in order of increase of the ratio $\frac{G+C}{A+T}$ in their deoxyribonucleic acid. The details have been published elsewhere[4].

The correlation is shown in Fig. 1, where the values of $\left(\frac{G+C}{A+T}\right)_{\text{DNA}}$ are plotted against those of $\left(\frac{G+C}{A+U}\right)_{\text{RNA}}$, each point corresponding to a species having characteristic values of the two ratios. There appears to be a positive correlation between the ratios $\left(\frac{G+C}{A+U}\right)_{\text{RNA}}$ and $\left(\frac{G+C}{A+T}\right)_{\text{DNA}}$ for the nineteen bacterial species studied; the correlation coefficient is 0·72, with a mean error of 0·17; that is, $r = +0{\cdot}72 \pm 0{\cdot}17$. The correlation coefficient is thus 4·3 times as large as its mean error.

The fact that the value of regression of $\left(\frac{G+C}{A+U}\right)_{\text{RNA}}$ on $\left(\frac{G+C}{A+T}\right)_{\text{DNA}}$ is very small explains why one encounters difficulties in studying the differences in composition of the ribonucleic acid of species differing drastically in the composition of their deoxyribonucleic acid.

It should be noted that the positive correlation between the compositions of the two nucleic acids has been established for only nineteen species of bacteria: further investigations are therefore necessary to show that this correlation is not fortuitous.

Nevertheless, our results suggest that part at least of the ribonucleic acid of the cell depends on the deoxyribonucleic acid, and that the two nucleic acids may even be similar with respect to their base compositions. On the other hand, the small value of the regression indicates that the greater part of the cell ribonucleic acid is relatively independent of the deoxyribonucleic acid.

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A Possible Mechanism for the Initial Transfer of the Genetic Code from Deoxyribonucleic Acid to Ribonucleic Acid

IT is now a generally accepted hypothesis that deoxyribonucleic acid contains the genetic information in the living cell which ultimately directs the formation of protein. Moreover, there is some evidence that deoxyribonucleic acid acts as a template for the formation of ribonucleic acid which relays information to the protein polypeptide chain by another template mechanism. If this were so there should be a simple relation between the composition of ribonucleic and deoxyribonucleic acids, since there are only four commonly occurring base groups in each nucleic acid. The fact that this is not so is probably due to two factors: only a fraction of the nucleic acid in the cell functions as a template and, therefore, only this fraction would be pertinent when comparing base ratios of the two nucleic acids; there are several different templates (more than two) involved in the transfer of information from deoxyribonucleic acid to the polypeptide chain, and, as a result the general problem of information transfer might be more easily solved by consideration of each template and its immediate chemical product.

As an example of this approach, consider the relation between the two nucleic acids and concentrate on the ribonucleic acid that is most likely to be produced directly on the deoxyribonucleic acid. I shall assume that this is nuclear ribonucleic acid because of its close cytological connexion with deoxyribonucleic acid. Furthermore, a good deal of evidence has accumulated that the cell nucleus plays a crucial part in the metabolism of ribonucleic acid[1].

This limitation makes it difficult to test any coding mechanism because of the paucity of pertinent data, for example, the base composition of deoxyribonucleic acid and nuclear ribonucleic acid. Nevertheless, I wish to propose the following code because it suggests further experiments. The data presented in Table 1 are taken from the results of Chargaff[2] and Vincent[3].

Since deoxyribonucleic acid and ribonucleic acid are each associated with four types of base groups, one might expect to find an immediate one-to-one correspondence between their respective bases. Chargaff's data do not verify this expectation however, and such a scheme is immediately discounted. The problem of finding four specific sites on deoxyribonucleic acid for binding ribonucleic acid has a possible solution resulting from the helical character of the duplex of the former which, in effect, gives rise to different binding sites being associated with a given nucleotide base-pair depending upon which polynucleotide chain the individual nucleotide members are situated. Thus adenine on chain I paired with thymine on chain II would make a different site from adenine on chain II and thymine on chain I. These two sites are designated as $A - T$ I and $A - T$ II. Likewise the other two sites are designated $G - C$ I and $G - C$ II. In this code each deoxyribonucleic acid base-pair functions as a location for one ribonucleic acid base-group in a single chain, the sequence of base-groups in the latter being determined by the sequence of base-pairs in the former acid. The particular correspondence I would like to suggest is shown in Table 2.

(1) This code predicts a necessary relation between the base composition of the two nucleic acids such

Table 1

Source of ribonucleic acid	Nuclear ribonucleic acid A/U	G/C	Pu/Py	$G+U/A+C$	$G+C/A+U$	Deoxyribonucleic acid $A+T/G+C$	Cytoplasm ribonucleic acid $G+C/A+U$
Rat liver	0·85	0·88	0·86	1·00	1·26	1·33	1·59
Ox liver	0·81	0·87	0·83	1·01	1·28	1·25	1·59
Ox kidney	0·99	0·88	0·83	0·94	1·26	1·30	1·52
Starfish oocyte	1·47	1·34	1·38	1·04	1·74	1·78	1·42

Abbreviations: A, adenine; G, guanine; C, cytosine; U, uracil; T, thymine; Pu, purines; Py, pyrimidines.

that the ratio $\frac{A+T}{G+C}$ of the deoxyribonucleic acid should be equal to the ratio $\frac{G+C}{A+U}$ of the ribonucleic acid. Reference to columns 6 and 7 in Table 1 giving the nucleotide compositions indicates that this relation holds. Two other relations for base ratios produced by this code depend on the relative composition of the individual deoxyribonucleic acid chains: (2) The 6-amino/6-keto ratio of ribonucleic acid depends upon the relative purine/pyrimidine ratio of the two deoxyribonucleic acid chains and is equal to one when both these chains contain the same relative amounts. (3) The purine/pyrimidine ratio of the ribonucleic acid depends upon the relative 6-amino and 6-keto content of the two deoxyribonucleic acid chains and is equal to 1 when these two chains contain the same relative amounts. From Table 1 we see that the relevant ribonucleic acid base ratios are not far from 1, although the 6-keto/6-amino ratio seems much closer to 1. It should be noted that I have not specified to which deoxyribonucleic acid chains I and II refer, and also that the code could be altered by interchanging the assignments for $A - T$ I and $A - T$ II (a template model has been built which would suggest that if the general code described here is correct, the assignments for $A - T$ I and $A - T$ II in Table 2 should be interchanged). This would have the effect of interchanging relations 2 and 3. In view of the fact that we have no data on the relative composition of the two chains we have no reason for preferring one system to the other. Moreover, there are so few data relevant to the proposal made here that we cannot be confident that the correlation found is general.

Table 2

DNA base pair	RNA base determined
A–T I	guanine
A–T II	cytosine
G–C I	uracil
G–C II	adenine

Work is in progress in this Research Unit to test the proposed code.

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Catechol Amine Depletion in the Rat's Denervated Adrenal Gland following Chronic Administration of Reserpine

RECENT observations have indicated that reserpine can depress not only 5-hydroxytryptamine, but also noradrenaline- and adrenaline-levels in brain, heart, spleen and other sympathetically innervated tissues[1-3]. The depletion of adrenal medullary hormones by single doses of reserpine has been attributed to a stimulation of centres in the central nervous system, since spinal transection at T_1 is reported to prevent this response[1].

In the present study the effects of chronically administered reserpine ('Serpasil') on the catechol amine content of the denervated and innervated adrenal glands of the rat have been investigated. Male litter mates, weighing approximately 250–300 gm. were used throughout. The left adrenal gland was denervated aseptically, approximately 7–10 days prior to the administration of reserpine. The reserpine was given intraperitoneally in a dose of 0·1 mgm./100 gm. for a period of 5 days. The control group of animals received a placebo which consisted of the reserpine diluent. The catechol amine content of the glands was extracted at 4° C. in a glass homogenizer using 5 per cent trichloracetic acid. The acid was removed by washing the extract with 3 volumes of peroxide-free diethyl ether[4]. Bio-assay was performed using the cat's blood pressure in a preparation which had been pretreated with hexamethonium, atropine and diphenhydramine[5]. Total catechol concentrations were obtained in noradrenaline equivalents. All results were subjected to set or paired comparisons using the t-ratio for the determination of statistical significance.

A marked depression in catechol amine-levels was obtained in both the denervated and innervated glands after the administration of reserpine for 5 days (Table 1). A comparison with placebo-treated controls indicated that this depletion was of a high order of significance (Table 2; 1, 2). The innervated and denervated glands in each of the two experimental groups when subjected to a paired comparison revealed no significant differences (Table 2; 3, 4). This suggests that reserpine may deplete the denervated gland to about the same degree as the innervated one.

These results demonstrate that the depleting action of reserpine on medullary amines may occur in the

Table 1. ADRENAL MEDULLARY CATECHOL AMINE-LEVELS (μGM./KGM. BODY-WEIGHT)

	Placebo		Reserpine	
	Mean ± S.E.M.	No. of animals	Mean ± S.E.M.	No. of animals
Innervated gland	22·2 ± 2·8	12	11·5 ± 2·0	14
Denervated gland	21·5 ± 1·4	12	10·5 ± 1·7	14

Table 2. Statistical Analysis

	Comparison	Method of analysis	P value
1	'Serpasil' (*D*)—Placebo (*D*)	Group comparison	<0.01
2	'Serpasil' (*I*)—Placebo (*I*)	Group comparison	<0.01
3	'Serpasil' (*D*)—'Serpasil' (*I*)	Paired comparison	>0.2
4	Placebo (*D*)—Placebo (*I*)	Paired comparison	>0.5

D, Denervated gland ; *I*, innervated gland.

absence of any direct neural connexion with the central nervous system.

Since chronic reserpine administration causes the release of both noradrenaline and adrenaline from the rat's adrenal gland and does not apparently impede the normal rate of re-synthesis of these substances (ref. 6 and B. L. Mirkin, unpublished results), it is probable that the peripheral effect which has been observed is due to some action on those mechanisms which regulate the storage and release of catecholamines from the adrenal medulla. This aspect of the problem is at present under investigation.

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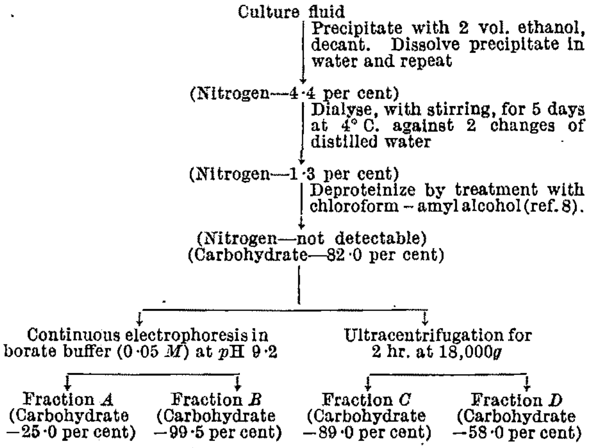
Extracellular Metabolic Products of a *Hirsutella* Species

A species of *Hirsutella*, parasitic on larvæ of the spruce budworm (*Choristoneura fumiferana* (Clem.))[1], when grown in liquid culture produces a highly viscous metabolite. Preliminary tests indicated that this substance might be a polysaccharide and since it has been reported that polysaccharides produced by some parasitic fungi can cause significant reactions in the host[2], it seemed desirable to investigate this material.

The fungus was grown in a liquid medium containing 1 per cent glucose and 1 per cent 'Difco' yeast extract. 100-ml. portions of the sterile medium in 250-ml. flasks were inoculated, incubated for 7–10 days at 25° C. on a rotary shaker, pooled, centrifuged, and the supernatant fluid collected.

The addition of two volumes of ethanol or acetone to one volume of the culture fluid precipitates the viscous material. Spot tests on this precipitate gave positive results for the presence of carbohydrates and proteins and/or amino-acids. Reducing sugars were detected only after acid hydrolysis of the sample. Negative results were obtained in tests for pentoses, galactose and glucuronates, while ether extraction of an acid hydrolysate of the sample gave no evidence for the presence of lipids.


Culture fluid
Precipitate with 2 vol. ethanol, decant. Dissolve precipitate in water and repeat
(Nitrogen—4·4 per cent)
Dialyse, with stirring, for 5 days at 4° C. against 2 changes of distilled water
(Nitrogen—1·3 per cent)
Deproteinize by treatment with chloroform – amyl alcohol (ref. 8).
(Nitrogen—not detectable)
(Carbohydrate—82·0 per cent)
Continuous electrophoresis in borate buffer (0·05 M) at pH 9·2
Ultracentrifugation for 2 hr. at 18,000g
Fraction A (Carbohydrate —25·0 per cent)
Fraction B (Carbohydrate —99·5 per cent)
Fraction C (Carbohydrate —89·0 per cent)
Fraction D (Carbohydrate —58·0 per cent)

The material was purified as in the scheme above. During the fractionation in the continuous electrophoresis apparatus fraction *A* was collected directly below the point of application. Fraction *B* migrated toward the anode but was carried down the paper at such a slow rate that it had not reached the bottom edge before the end of the run. However, as the streak was clearly visible it was cut from the paper, eluted with water, filtered through a sintered glass funnel to remove cellulose fibres, and freed of borate[3].

When the deproteinized culture fluid was centrifuged for 2 hr. at 180,000*g*, it yielded a semi-solid sediment and a non-viscous supernatant which could be siphoned off. The sediment (after washing 4–6 times with water) and the supernatant were freeze-dried and designated fractions *C* and *D* respectively.

The time-reaction curves of all four fractions with anthrone were, in general, similar to those reported by Koehler[4] for the polyhexoses glycogen, dextrin and amylose. The shape of these curves indicated that the samples contained aldohexoses only.

Hydrolysis of the samples by refluxing with 1 *N* sulphuric acid resulted in the formation of considerable amounts of humin and almost complete destruction of the sugars. However, by heating with 2 *N* formic acid in sealed tubes at 120° C. complete hydrolysis could be obtained with destruction of less than 5 per cent of the carbohydrates. Chromatograms of the hydrolysates of fractions *A* and *B* showed three spots, two of which were identified as glucose and mannose but the third was not identified. When hydrolysates of fractions *C* and *D* were subjected to chromatography only two spots, corresponding to glucose and mannose, were apparent. It appeared, therefore, that the third component in fractions *A* and *B* might be an artefact formed during the fractionation by electrophoresis, possibly due to the long exposure to alkali.

The sugars were also identified by filter paper electrophoresis of the hydrolysates[5]. Glucose was further confirmed by treating the hydrolysates with glucose oxidase. Chromatography of the treated samples showed that one spot, corresponding to the glucose standard, had disappeared.

The infra-red spectra of the fractions gave some additional information on the nature of these carbohydrates. A peak at 890 ± 10·5 cm.$^{-1}$ in all the samples can be attributed to a β-linkage in the polysaccharides. There was no evidence of a peak at

844 cm.$^{-1}$ in any fraction, which indicates that the α-linkage is not present to any extent in these samples[6]. All four fractions gave a peak (814 ± 9·5 cm.$^{-1}$) which appeared to be similar to a type 3 peak of mannan. Other peaks given by fractions *A* (917 cm.$^{-1}$) and *B* (947 ± 1·4 cm.$^{-1}$; 774 ± 1·2 cm.$^{-1}$) are typical of hexoses in general and could not be attributed to any particular sugar[7].

Sedimentation curves gave an indication of the homogeneity of the samples. The deproteinized, but unfractionated sample was heterogeneous but contained two principal components. Fraction *A* was heterogeneous with no predominant component but fraction *B* gave a single, sharp peak indicating that it was relatively homogeneous. Both fractions *C* and *D* were heterogeneous, but each contained one main component.

This fungus produces a number of extracellular polysaccharides, though there appear to be two main constituents in the mixture. While these polysaccharides are similar in some respects, for example, constituent sugars and β-linkages, there are differences in molecular weights and in viscosities. The one polysaccharide isolated in a relatively pure form differs from the others in that it can form a charged complex with borate. Since the formation of borate complexes depends on the location of free hydroxyl groups in the polymer, a difference in the position of the glycosidic linkage in the polymers may be indicated.

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Purine Excretion by the Sheep Ked, *Melophagus ovinus* (L.)

THE major nitrogenous excretory product of adult insects is uric acid[1]. Small amounts of the enzymes adenase and guanase have been reported in *Hydrophilus* and *Dytiscus*[2] and in *Prodenia* and *Tenebrio*[3]. Larvæ and pupæ of *Antheraea pernyi* Guér. (Lepidoptera) contain adenine, hypoxanthine and xanthine[4]. At Lethbridge, female sheep keds have been found to excrete xanthine and hypoxanthine as well as uric acid. Male keds excreted only uric acid.

Purines were determined chromatographically by adapting the method of Vischer and Chargaff[5]. Direct squashes of the hæmolymph, Malpighian tubules, and iliac bulb contents of two or three insects were made on Whatman No. 4 filter paper, each squash being treated with 0·5 *N* sulphuric acid after spotting. About 0·05 ml. of a standard mixture (hypoxanthine, 0·1 per cent; xanthine and uric acid, saturated solutions) in 0·5 *N* sulphuric acid was spotted on the paper and run beside the squashes. Chromatograms were run by the descending technique for 16 hr. in a system composed of *n*-butanol/diethylene glycol/water (4 : 1 : 1), in an atmosphere saturated with this material and with ammonia. The latter neutralized the sulphuric acid used in spotting the standards and samples. Chromatograms were air-dried, oven-dried for 30 min. at 40° C., sprayed with a 0·5 *M* solution of mercuric nitrate in 0·5 *N* nitric acid, washed in 0·5 *N* nitric acid and running tap-water, and developed in ammonium sulphide solution. Purines appeared as black spots of mercuric sulphide.

Great variation was noted in the amounts of xanthine and hypoxanthine from random samples of female keds, and an attempt was made to discover the source. Chromatograms of hæmolymph, tubules, and iliac bulb contents of females containing no larva in the vagina showed only uric acid, whereas those containing a small larva exhibited traces of xanthine as well. Squashes from females containing a large larva produced xanthine spots as dense as or denser than the uric acid spots, as well as small spots of hypoxanthine, which was usually demonstrable only in the iliac bulb contents. It was concluded that the xanthine and hypoxanthine were produced in larval metabolism.

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Formation of Antifungal Antibiotics by a New *Streptomyces* Species

Two closely similar strains of a new species of *Streptomyces* (Nos. 1033 and 1038) were isolated from the Champavathi river mud (Andhra Pradesh) and Bangalore virgin soil (Mysore State). Their morphological and biochemical characteristics (Table 1) appear similar to those of *Streptomyces viridans* (Waksman and Henrici's classification)[1], but they are readily differentiated from the latter by the formation of straight sporophores and aerial mycelium in circles and tufts, and the elaboration of antifungal substances.

A mixture of three antibiotics, *A*, *B* and *C*, extractable with *n*-butanol from broths and mycelia, is formed after growth for 48–72 hr. in shake-cultures containing molasses and peptone at 28° C. None of them has yet been obtained in the crystalline state. These are characterized by a high degree of inhibitory activity (0·2–0·5 μgm./ml.) *in vitro* against *Saccharomyces cereviseae*, *Candida albicans*, *C. tropicalis*, *Zygosaccharomyces priorianus*, *Torulopsis pulcherimma*, *T. utilis*, *Rhodotorula glutinis*, *Geotricum* sp. and a few other fungi tested. They are inactive towards *Micrococcus pyogenes* var. *aureus*, *Escherichia coli* and *Bacillus subtilis*. The mixture of the antibiotics separates into three spots (R_F values, 0·0; 0·33 and 0·95, respectively) on one-dimensional ascending paper chromatograms (Whatman No. 1 paper) developed with benzene/acetic acid/water (2 : 2 : 1 —organic layer) at 26° C. While *A* and *B* give

Table 1. Characteristics of the Organisms after Incubation for Seven Days at 28° C.

Media (ref. 2)	Description of colony	Reverse side	Aerial mycelium	Soluble pigment
Yeast-glucose agar	Good growth, round, raised; older colonies often cleave	Moss green	Light grey with greenish tinge, concentric, abundant velvety rings and tufts. Sporophores curved; spores globose	Greenish, darkening later
Nutrient salt agar	"	"	"	"
Glucose-peptone agar	"	"	"	Slight
Meat peptone agar	As above, but flattened; growth, poor	Yellowish green	"	None or faint
Emerson's agar	As on yeast-glucose	Moss green	"	Yellowish green
Bennet's agar	"	"	"	"
Potato-glucose agar	"	Deep reddish brown	"	Negligible
Starch agar	Small and flattened (starch hydrolysed)	Moss green (formation slow)	"	Faint
Czapek's agar	"	Yellowish green	As above, but less abundant	Nil
Calcium malate agar	Small, round, raised, yellow vegetative mycelium. Digestion of the salt	Yellow with brownish centre	As above (excepting the peripheral region)	Nil
Egg-albumin agar	Thin, spreading; growth: slow, poor and colourless	White or pale yellow	As above, but poor and slow	Nil
Glucose–asparagine agar	With elevated centre; slow growth	Yellowish green	"	Nil
Gelatin liquefaction	Complete in 6–7 days			
Nitrate reduction	After 6–7 days			
Milk	Peptonizes completely after 10 days; alkaline			

Carbon compounds utilized for growth: arabinose, glucose, galactose, sucrose, maltose, starch.
Carbon compounds not utilized for growth: raffinose, rhamnose, lactose, dulcitol, sorbitol.

absorption curves ($\lambda_{max.}$ 360, 380, 405 mμ) characteristic of the heptaene group[3], no selective absorption is noticeable in the case of *C* in the region of 250–400 mμ. Their chromatographic behaviour on paper strips (developed with various solvent systems[4]), solubility and spectral characteristics, and antimicrobial activity together indicate that, in any event, *B* and *C* are entirely different from any known and well-characterized antifungal substances formed by *Streptomyces* species.

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Toxicity of Urea to Sheep

It is generally accepted that urea is toxic when fed at levels greater than 30–35 gm. per sheep a day. Clark *et al.*[1] produced toxic effects by drenching sheep with 10 gm. of urea. Peirce *et al.*[2] killed many sheep when they fed 25–45 gm. of urea per sheep a day; in this experiment, the daily ration of urea was consumed over a period of approximately 1 hr. By adjusting the method of feeding, we have found it possible to feed sheep up to 100 gm. of urea a day with no mortality.

Although the mechanism of urea toxicity is not fully understood, it is thought to be related to the production of ammonia by the rapid hydrolysis of urea in the rumen. This rise of rumen ammonia produces a rise of peripheral blood ammonia, and toxicity occurs when blood ammonia concentration rises above 8–12 μgm. ammonia–nitrogen/ml. However the ammonia concentration in peripheral blood does not rise until the rumen ammonia-level is raised above about 80 mgm. ammonia–nitrogen/100 ml.

It follows, therefore, that if the urea can be fed in such a way that rumen ammonia-levels never rise above 80 mgm. ammonia–nitrogen/100 ml., then no toxicity will result. This can be done by spraying the urea in solution over the sheep's ration of hay, or over the pasture which it is grazing. In this way, the daily ration of urea will be consumed in small quantities at intervals over the whole 24-hr period. Since ammonia is rapidly absorbed from the rumen, there will be no great build up of rumen ammonia.

A Corriedale wether weighing 58·5 kgm., and fitted with a permanent rumen fistula, was kept in a metabolism cage and fed a daily basal ration of 1,400 gm. chopped meadow hay (crude protein 7·0 per cent). From day to day, this was supplemented with varying amounts of urea and molasses, these being incorporated into the ration as a solution in water mixed thoroughly with the hay. The urea : molasses ratio by weight was kept at 1 : 4. Rumen samples were taken immediately before feeding and then at regular intervals after feeding for periods up to 24 hr. Rumen *p*H and rumen ammonia concentration were measured on each sample.

Fig. 1 shows rumen ammonia concentrations over a 14-hr. period after feeding 100 gm. of urea, and, for comparison, the effect of introducing 25 gm. of urea directly into the rumen, and of feeding hay alone. When 100 gm. of urea were fed with the hay, rumen ammonia-levels rose sharply and remained at high levels throughout the day, the levels fluctuating slightly according to times of eating. However, at no time did these levels rise above 80 mgm. ammonia–nitrogen/100 ml. Similar results have been obtained

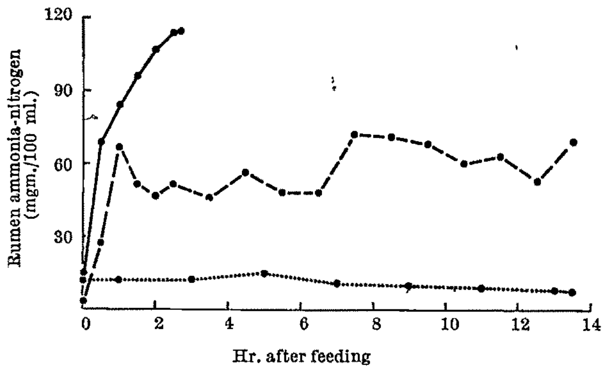

Fig. 1. The effect of different ways of feeding urea on rumen ammonia-levels: ● · · · ●, hay alone; ● – – ●, hay sprayed with 100 gm. urea + 400 gm. molasses; ● — ●, hay diet, 25 gm. urea through fistula

with other sheep both in metabolism cages and under field conditions.

Clearly, where urea is to be used as a supplement for grazing animals, it is desirable to feed it as a spray rather than as part of a concentrated ration, because toxicity is then no longer a problem. However, whether it is beneficial and economic to feed very high urea levels is doubtful.

It is interesting to note that when high levels of urea are fed, rumen *p*H rises to nearly 8, and both rumination and rumen movement are inhibited. Whether this rumen paralysis is caused by the ammonia *per se*, or is a consequence of rumen alkalosis, or is an osmotic effect, is not yet clear.

This work is continuing, and will be published in full elsewhere.

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Heparin Content of Adipose Tissue

There is now a well-established association between heparin and clearing factor[1,2] and between heparin and the mast cell[3]. It has long been known by histologists that mast cells "are numerous in parts where fat is being laid down"[4]. This, and the extraction of active clearing factor preparations from adipose tissue[5], suggested to us that heparin might be an essential agent in fat mobilization and deposition, and in consequence be present in all animal fat. As a preliminary step we have determined the amount of heparin in the adipose tissue of cattle and the study forms the subject of this communication.

The tissues, already carefully trimmed, were kindly supplied by Mr. A. J. Ross of the Glasgow Abattoir and his description of them appears in Table 1.

Table 1. The Heparin Content of Bovine Adipose Tissue before and after Defatting

Type of fat	I.U./gm. whole adipose tissue	I.U./gm. of defatted adipose tissue residue
Intestine	0·92	21·6
Rectum and anus	1·5	60·0
Liver	1·3	45·3
Cardiac	1·0	40·3
Uterus	2·0	56·9
Lung	3·89	130·5
Kidney	0·44	28·7
Tongue	0·88	28·3
Mesentery	1·5	45·01
Stomach	0·9	59·0

Each sample of approximately two kilos was defatted with hot alcohol and the fibrous residue dried *in vacuo*. The heparin was then extracted as follows.

The defatted tissue was homogenized in 10 per cent aqueous ammonium carbonate, heated to 70° C. and filtered. The residue was twice re-extracted using further ammonium carbonate solution and the extracts were combined. The crude heparin was precipitated with two volumes of alcohol, collected by centrifuging and dried. The precipitate was taken up in ammoniacal water to give a gelatinous solution which was treated with trypsin and then assayed for heparin.

We are indebted to our colleague Mr. J. Pritchard for the anticoagulant assays[6], and on a random selection of samples he also demonstrated that the anticlotting activity was inhibited by protamine, indicating that the activity was due to heparin or similar substances.

Table 1 summarizes the results and shows that all samples contain heparin in appreciable amounts.

We are indebted to the Directors of Evans Medical Supplies for providing the facilities to carry out this work.

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Difference between Lipoprotein Lipase and Post-Heparin Esterase in Human Serum

The basic component of the clearing factor[1] is a lipolytic enzyme which differs from hitherto known lipases[2]. Its lipolytic action can be demonstrated by the hydrolysis of the fatty components of lipoproteins[3]. When using β-naphthyl laurate[4], acetylcholine and butyrylcholine[5] as substrate the results are negative. With tributyrin the findings are conflicting[6]. If ethyl butyrate is used as substrate, raised esterolytic activity of the sera can be observed in man after the intravenous injection of heparin[7].

We consider that the acceleration of hydrolysis of ethyl butyrate is the result of the action of an enzyme other than the lipase of the clearing factor, which is definitely inhibited by protamine and heparin *in vitro*[8]. As against this, the post-heparin esterase splitting of ethyl butyrate is not inhibited by these substances (Table 1).

Table 1. The Resistance of Post-Heparin Esterase to Inhibition by Protamine and Heparin *in vitro*

Inhibitor of lipoprotein lipase	Amounts of inhibitor added per ml. serum	Esterase activity per ml. (μmol. of acid liberated from ethyl butyrate in 24 hr.) Pre-heparin serum	Post-heparin serum
Protamine	1,000γ	130	167
	100γ	131	166
	Control	130	167
Heparin	1,000 units	133	195
	100 units	135	198
	Control	135	195

In vitro, protamine inhibits post-heparin esterase only when it is added in excess[9]. Ordinary amounts, which inhibit the lipase of the clearing factor, have no effect, however, on post-heparin esterase. In accord with the findings of Levy and Swank[10], we found that protamine has an inhibitory effect on the activity of post-heparin esterase *in vivo*[11]. It may therefore be concluded that heparin produces an increase of esterase in the blood-stream, but that it does not form a component part of the molecule of this enzyme. As opposed to this, lipoprotein lipase contains heparin or a similar substance, which explains its inhibition by protamine *in vitro* and its destruction by heparinase[12].

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Interaction of Gibberellic Acid and Photoperiod on the Vegetative Growth of *Pinus elliottii*

CONIFERS have not been very responsive to treatment with gibberellic acid. A definite stimulation of extension growth was obtained by Marth *et al.*[1] in only two of the five species investigated, *Pinus virginiana* Mill., and *Juniperus chinensis* f. *Pfitzeriana* Spaeth. Measurable, but not significant, increases in height growth of treated *Pinus strobus* L. have been reported[2]. Radicles of germinating seeds of *Pseudotsuga menziesii* (Mirb.) Franco elongated more rapidly if wetted with weak solutions of gibberellic acid[3].

The effect of this chemical on stem growth has generally been tested under natural photoperiod or under long days. The results presented here indicate that gibberellic acid promotes the growth of slash pine, *Pinus elliottii* Engelm., only under short-day conditions.

Shortly after emergence in February 1957, the pine seedlings were submitted to one of the following photoperiods: 8, 16 and 24 hr.; and natural day-length. The supplementary light was provided by incandescent bulbs giving an intensity of about 20 foot-candles at the level of the plant tips. Shoot elongation increased with increasing photoperiod. After four months, the average height of the seedlings under short days (8 hr.) was equal to 44 per cent of those in continuous light, whereas the 16-hr.-day plants were 70 per cent as high. Even in continuous light, slash pine elongates by flushes of growth, once it has formed secondary needles. The short-day seedlings produced only two flushes separated by a long time-interval. Practically no growth in height occurred in these seedlings between June and December. Starting then, half of them were sprayed, once every 14 days, with a 0·1 per cent aqueous solution of 'Gibrel' (potassium gibberellate) to which a few drops of a wetting agent had been added. Prior to spraying, the plants were slightly wounded by breaking off several primary needles to facilitate penetration of the chemical. The controls were subjected to the same mechanical injury.

Fifteen days after the first application, the terminal buds of several seedlings were swollen and had elongated slightly. One week later, 14 out of 25 treated plants had broken dormancy, and, one month after the initiation of the treatments, they were all actively growing. Most control plants began to break dormancy shortly after the treated plants but their height-growth lagged and stopped earlier. By May 15, the treated seedlings had grown an average of 67 mm. (52 per cent of initial height), significantly more than the controls (30 mm., or 24 per cent of initial height).

Gibberellic acid was also applied, as a spray and in a 1 per cent lanolin paste, to seedlings growing under natural and 16-hr. photoperiods and in continuous light. There was a small, but not significant, increase in average height-growth in natural day-length (11–12 hr. at that time), but no response was observed under long days.

In another experiment, four-month-old seedlings, that had been growing actively under 16-hr. days, were submitted to 8-hr. days in order to induce dormancy. This condition was obtained in 2–4 weeks. Gibberellic acid sprays were then administered at weekly intervals. The first signs of growth resumption appeared one month after the first treatment. Three months later, the forty treated plants had elongated by 26 mm. on the average, or 16 per cent of initial height, whereas the controls produced new needle fascicles but very little shoot-growth (8 mm. on the average, or 5 per cent of initial height). Seedlings of the same age submitted to long days showed no detectable response to the chemical.

It seems that, in slash pine, gibberellic acid is able to break the type of bud dormancy induced by short-day treatment, and to stimulate the growth of elongating shoots exposed to short photoperiods. The lack of response to the chemical in the long-day treatments suggests that the natural gibberellin factor becomes deficient, in this species, only under short days. In contrast to slash pine, two other conifers, *Pinus coulteri* D. Don and *Pseudotsuga macrocarpa* (Vasey) Mayr, did not respond to gibberellic acid under short days (while *Camellia japonica* L., an evergreen angiosperm, reacted positively)[4].

Interactions between gibberellic acid and photoperiod have also appeared in a preliminary study on bud-break in deciduous species. In some of these (for example, *Acer platanoides* L.), the chemical hastened bud opening to a greater extent under short days than under long days.

Acknowledgments are due to Dr. Richard M. Klein for advice. The 'Gibrel' was presented by Merck and Co., Inc.

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Cocoa Shade and Manurial Experiment in Ghana

Contrary to general experience with other world crops, cocoa grown in West Africa had never been shown to respond to fertilizer, for reasons discussed by T. N. Hoblyn[1]. The recent successful control of capsid pests and the availability of uniform cocoa, however, has now made accurate experimentation possible.

In October 1956, at this Institute an area containing ten-year-old Amelonado trees planted in straight lines at 8 ft. × 8 ft. under uniform *Gliricidia maculata* shade (24 ft. × 24 ft.) was chosen for shade removal and fertilizer application. The trees were in their third year of bearing and pre-treatment records were available. Fifteen plots, each containing 300 trees, were marked out. The treatments applied were: original shade/no fertilizer; original shade/fertilizer mixture; no shade/no fertilizer; no shade/fertilizer mixture. All treatments are replicated three times, each replicate having 300 trees, thus making a total of 3,600 experimental trees. The three extra plots form guard plots between shaded and unshaded cocoa.

The fertilizers were broadcast by hand, and the types, rates and times of application are shown in Table 1.

Table 1

Application	Date	Fertilizer used in mixture	Rates (lb./acre) N	P_2O_5	K_2O	MgO
1	Oct. 1956	Ammonium phosphate (11 per cent N, 46 per cent P_2O_5) Single superphosphate (18 per cent P_2O_5) Sulphate of potash (48 per cent K_2O) Magnesium sulphate (16·2 per cent MgO)	13	91	90	46
2	April 1957	Urea (46 per cent N) Triple superphosphate (47 per cent P_2O_5)	50	30	—	—
3	Sept. 1957	Urea	50	—	—	—

The shade was removed from all the non-shaded plots by poisoning the shade trees with 'Phortox' in March–April 1957.

The yields, expressed in pounds dry cocoa per acre, after one year of treatment are given in Table 2.

Table 2. Yields expressed in lb. Dry Cocoa/Acre

Treatments	First fertilizer mixture applied October 1956. Shade removed March 1957. Pretreatment yields 1954–55	1955–56	1956–57	After treatment yields 1957–58
Original shade/no fertilizer	30	44	205	615
Original shade/fertilizer mixture	24	32	211	869
No shade/no fertilizer	19	29	170	1,079
No shade/fertilizer mixture	20	18	173	1,574

Shaded/fertilized, unshaded/fertilized and unshaded/unfertilized treatments all showed significant increases in yield compared with the shaded/unfertilized control when an analysis of covariance was carried out. It is realized that one year's results are not sufficient to provide any definite general conclusions; but the sparsity of published information about the responses of cocoa to such treatments, especially in West Africa, has caused us to report these preliminary results. Fuller details of the investigations will be published elsewhere.

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Inheritance of Photoperiodic Reaction in Rice

Aus (summer) and *Aman* (winter) are the two important types of rice cultivated in Bengal, north-east India. The majority of the varieties of summer rice are photo-indifferent (period bound), while all the winter varieties are short-day (season bound) plants[1,2].

In practice, both summer and winter varieties are sown at the same time, at the beginning of the rice season in May–June, when the advent of rains ensures plenty of moisture required for good growth of the crop. The summer varieties, which are photo-indifferent, flower about 90 days after sowing and are ready for harvest in another month, in September. The winter varieties, which are short-day plants, do not flower until the length of the day decreases to less than 11·5 hr., in October–November. These varieties are harvested in November–December. As a rule, however, the winter varieties are much heavier yielders and better in grain quality than the summer varieties. It is of interest, therefore, to elucidate the inheritance of photoperiodic reactions in summer and winter rice, with the view of combining the early harvesting of the summer varieties with the high yield and good grain qualities of the winter varieties.

Reciprocal crosses were therefore attempted during the season of 1956 with plants, grown in pots, of two summer varieties, namely *Charnock* and *Dhairal*, and two winter varieties, namely, *Patnai*–23 and *Bhasamanik*, there being in all eight different combinations of crossings.

The combinations employed, the number of crosses actually attempted, the numbers of seeds gathered and of seeds germinating in the following season, and the number of plants showing hybrid characters under the respective combinations are shown in Table 1.

For these crosses flowering coincidence was effected in two ways. First, flowering of the winter varieties was hastened by short-day treatment to coincide with flowering of the summer varieties in their normal season. Secondly, a series of sowings of the summer varieties was made at fortnightly intervals until the end of August, to obtain coincidence of their flowering

Table 1

♀ Parent		♂ Parent	No. of flowers cross-pollinated	No. of seeds produced	No. of seeds germinated	No. of plants showing hybrid (F_1) characters
(1) *Bhasamanik*	×	*Dhairal*	44	15	14	1*
(2) *Dhairal*	×	*Bhasamanik*	37	8	5	1
(3) *Patnai*-23	×	*Dhairal*	18	9	9	2
(4) *Dhairal*	×	*Patnai*-23	31	9	9	1
(5) *Bhasamanik*	×	*Charnock*	33	6	4	1
(6) *Charnock*	×	*Bhasamanik*	16	1	0	0
(7) *Patnai*-23	×	*Charnock*	29	8	7	0
(8) *Charnock*	×	*Patnai*-23	45	7	5	4

Table 2

Parent varieties	Time taken from sowing to flowering (days)	Height (cm.)	Tillering (No.)	Grain yield: Weight (gm.)	Grain yield: No. (approx.)
(1) *Patnai*-23 (winter var.)	188·1 ± 2·6	124·4 ± 3·3	8·6 ± 0·6	3·2 ± 0·3	125
(2) *Bhasamanik* (winter var.)	184·4 ± 2·9	106·8 ± 1·6	10·3 ± 0·7	2·5 ± 0·1	175
(3) *Charnock* (summer var.)	92·8 ± 0·7	94·3 ± 2·5	5·7 ± 0·8	2·8 ± 0·4	180
(4) *Dhairal* (summer var.)	87·6 ± 0·6	93·4 ± 1·8	3·9 ± 0·4	3·3 ± 0·4	125
F_1 Hybrids					
(1) *Patnai*-23 ♀ × *Dhairal* ♂	144·0	125·0	12·0	6·9	250
(2) *Patnai*-23 ♀ × *Dhairal* ♂	136·0	145·5	11·0	22·2	850
(3) *Dhairal* ♀ × *Patnai*-23 ♂	136·0	143·5	18·0	15·5	550
(4) *Bhasamanik* ♀ × *Dhairal*-23 ♂	138·0	130·0	25·0	16·9	800
(5) *Dhairal* ♀ × *Bhasamanik* ♂	139·0	119·5	21·0	6·2	300
(6) *Charnock* ♀ × *Patnai*-23 ♂	135·0	134·0	18·0	13·3	600
(7) *Charnock* ♀ × *Patnai*-23 ♂	136·0	136·0	15·0	18·5	850
(8) *Charnock* ♀ × *Patnai*-23 ♂	136·0	135·0	10·0	6·95	300
(9) *Charnock* ♀ × *Patnai*-23 ♂	137·0	138·0	11·0	8·9	350
(10) *Bhasamanik* ♀ × *Charnock* ♂	142·0	119·0	19·0	10·7	600

with that of the winter varieties in the normal season of the latter. The 'paper-bag' method was employed for opening flowers for emasculation[3].

In the season of 1957 the hybrid seeds were grown in pots to study their behaviour. Information on tillering, height, leaf size, flowering time and yield per plant was collected. Hybrid plants have been obtained from six of the eight combinations of crosses. Growth, flowering-time and yield of the hybrid plants, together with those of plants belonging to the parent varieties sown at the same time in 1957, are shown in Table 2.

The F_1 plants with all combinations of crosses show an intermediate effect on photo-periodic reaction, their flowering time being intermediate. The reciprocal crosses were identical.

In respect of growth characters, such as height, tiller number and yield, the F_1-hybrid plants of all six different combinations of crosses display hybrid vigour.

Further work is in progress.

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A New Species of *Azotobacter* producing Heavy Slime and Acid

In the course of an investigation on the geographical distribution of the Azotobacteriaceae[1] in various types of soil in India, a nitrogen-fixing organism has been isolated from a sample of red soil from Pattambi (Madras) by Winogradsky's silica-gel plate technique and purified by dilution platings. This new bacterium differs in certain morphological and physiological characteristics from known species of *Azotobacter* (including *Beijerinckia*)[1]. The cells are oval in shape, occur mostly in pairs and packets and sometimes singly, measuring on an average 1·2–2·2μ × 2·3–4·6μ (Fig. 1). The cells do not change their shape even on prolonged incubation in Ashby's nitrogen-free liquid medium with different carbohydrates. The bacterium encysts after 30 days incubation at 30° C. in the solid mannitol medium without calcium carbonate. The optimum temperature for growth was found to be about 30° C.

The colonies are usually raised, oval or circular and sometimes elongated with an average diameter of 2·95 mm. × 1·55 mm. on Ashby's nitrogen-deficient agar medium after 10 days incubation at 30° C. Colonies are transparent at first and gradually become opaque and sometimes curled if the medium is devoid of calcium carbonate. In streak cultures, the organism forms a slimy growth of variable thickness. In Ashby's nitrogen-free glucose or sucrose medium without calcium carbonate, the slimy masses at first accumulate on the surface of the medium, which is entirely transformed to a jelly-like consistency in about one month. Slime production is always associated with the growth of the organism. With calcium carbonate present in the medium, however, growth is depressed to some extent.

The organism is aerobic, non-motile, and the cells are Gram-negative. It produces no colour even on addition of a small amount (10γ per litre) of copper sulphate in Ashby's nitrogen-deficient agar medium[2], but some rust-brown sediment occasionally occurs in the nitrogen-free solid medium after six weeks incubation at 30° C. This sediment does not dissolve in alcohol, ether or chloroform.

The bacterium is usually resistant to certain basic aniline dyes, namely, crystal violet, gentian violet, safranine and methylene blue. However, staining is accomplished when the dyes are mordanted with phenol or aniline. The cells are stained by both basic carbol-fuchsin and aniline gentian violet on slight warming.

This bacterium produces acid from all the carbohydrates in nitrogen-free medium, especially glucose, sucrose, mannitol, starch, galactose, raffinose, mannose, maltose and dextrin. The development of acidity is the quickest in glucose, and is delayed

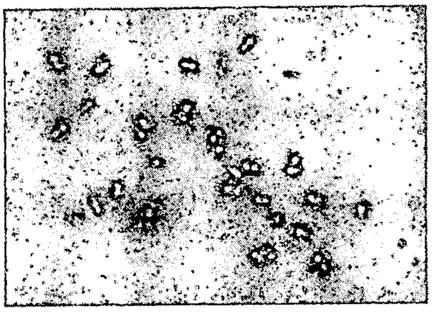

Fig. 1. *Azotobacter acidum*: a new species of *Azotobacter* producing heavy slime and acid. (× 500)

much in mannitol. Growth ceases when the *p*H of the medium falls below 4·0.

The organism fails to grow in organic sources of nitrogen, but with inorganic nitrogen (both with NH_4^+ and NO_3^-) the growth is accelerated with a rapid fall of *p*H and it ceases to grow after 10 days at 32° C. The bacterium does not grow either in nutrient broth or in peptone agar containing 0·5 per cent glucose. No gas is evolved during break-down of carbohydrates. In potato slants, cream-coloured growth appears in 4 days at 30° C. The organism can hydrolyse starch, and good amylase activity is observed after 6 days incubation at 30–32° C. It does not liquefy gelatine and produces no change in litmus milk during a period of 3 weeks at 30–32° C. The bacterium does not form indol or acetyl-methyl carbinol. It neither reduces nitrate nor produces ammonia.

The bacterium fixes on an average 8–10 mgm. of nitrogen per gram of glucose or sucrose added in Ashby's nitrogen-free solution without calcium carbonate after 3 weeks incubation at 32° C.

The organism differs from *Az. chroococcum* and *Az. beijerinckii* in that it forms acid from different carbohydrates and withstands acidity up to *p*H 4. Moreover, it produces no colour even on addition of copper sulphate. The cells are smaller and do not form streptococcus-like chains. The bacterium differs from *Az. agile* and *Az. vinelandii* in that it lacks motility ; it fails to grow in nutrient broth even with glucose and it does not form any fluorescent green pigment. Unlike *Az. indicum*, the cells lack fats and form cysts in the solid nitrogen-free carbohydrate medium. In Ashby's nitrogen-free medium with dextrin, *Az. indicum* fails to grow, while the new organism shows good growth. *Az. indicum* produces turbidity in the liquid medium with the formation of some sediment, but the new organism gradually changes the consistency of the medium to a semi-solid.

The differences between the morphological and cultural characters of the bacterium described here and other known species of *Azotobacter*[3] indicate that the organism is a new species. It is proposed that it should be named *Azotobacter acidum*, due to its property of forming acids from carbohydrates. Details of this work will be published elsewhere.

I am indebted to Dr. B. C. Kundu, director, and Dr. M. K. Mukherjee, chemist, Jute Agricultural Research Institute, for their help and encouragement.

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A New Type of Early Cysticercoid Stage in a Cyclophyllidean Cestode

Cysticercoids of various cyclophyllidean families are known to occur in small invertebrate hosts, commonly in arthropods and very occasionally in molluscs and annelids. During the course of some work on the pulmonate snail, *Oxychilus cellarius* (Müll) one of us noted a 3 per cent infection of the peritoneum around the digestive gland and gut with cysticercoids of what we believe to be a member of the Dilepididae, the first such record from a mollusc. The cysts numbered from one to about fifty in a single specimen and were seen in various stages of development, ranging from what we consider to be the pre-cystic stage to the fully formed, infective cysticercoid. The older cysticercoids with completely formed scolex and bladder resemble very closely the corresponding stage of another cysticercoid of the Dilepididae—that of *Choanotaenia infundibulum* (Bloch) described by Reid and Ackert[1]. A full account of these stages will be published later, but meanwhile we wish to direct attention to the earliest stage of this cysticercoid—a form which we regard as being pre-cystic and which, so far as we are aware, is unlike anything previously described.

From some of the younger cysts, the walls of which are adventitious host structures formed from peritoneum surrounding the parasite, tailed larvæ (Fig. 1) were extracted which were quite actively mobile in saline, bearing a marked resemblance in their movements to digenetic cercariae. We think that such a form must have been only very recently encysted, having reached its position by movement of the tail. Mobile, tailed larvæ of this kind have been reported only twice before in the Cestoda, in each case in the life-cycle of *Dipylidium caninum* L. by Grassi and

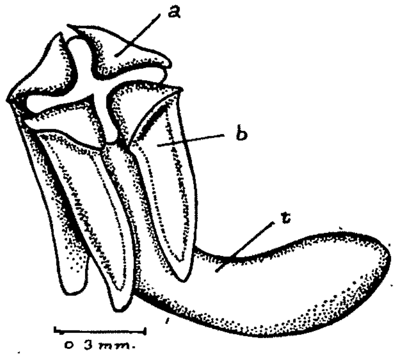

Fig. 1. Pre-cystic stage drawn from living specimen. For key see Fig. 2

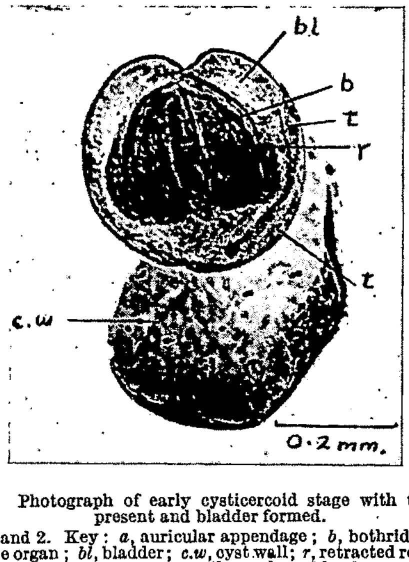

Fig. 2. Photograph of early cysticercoid stage with tail still present and bladder formed.

Figs. 1 and 2. Key : *a*, auricular appendage ; *b*, bothridium-like adhesive organ ; *bl*, bladder ; *c.w*, cyst wall ; *r*, retracted rostellum with double coronet of rose-thorn-shaped hooks ; *t*, tail

Rovelli[2] and Vennard[3]. The former writers compared its movements with those of cercaria, and Janicki[4] quotes this as part of the evidence for his 'Cercomer theory' in which he attempts to explain a possible derivation of the cestodes from the Digenea.

The tailed larva in the present work differs from any other tailed cysticercoid now known, either encysted or free, in possessing, instead of typical acetabula, four elongated muscular adhesive organs which resemble the bothridia of the Tetraphyllidea. It is not possible at present to say whether these structures are true bothridia or whether they are clearly demarcated at this stage from the rest of the scolex musculature, but they rapidly become acetabular by definition while still bothridia-like in shape, in the developing cysticercoid (Fig. 2). In the earlier stage (Fig. 1) each bothridium-like structure bears anteriorly an auricular appendage similar to those in the plerocercoid and adult of the tetraphyllidean *Dinobothrium plicitum* Lint. and also those of adult Tetrabothrioidea. As the cysticercoid approaches the infective stage, however, the whole muscular organ (bothridium-like structure plus its auricular appendage) resolves itself to form an acetabulum like that of typical Cyclophyllidea.

Whether or not this larva establishes affinity with the Digenea or Cestodaria or both must still be a matter of opinion; it is possible that similar tailed pre-cystic stages exist in other cyclophyllidean life-histories where encysted tailed cysticercoids have been described, for example, *Choanotaenia infundibulum* and various species of *Hymenolepis*. In these, as in *Dipylidium caninum*, the tailed condition would relate to the fluid medium supplied by the arthropod hæmocœle. It is possible that in the mollusc, which is most frequently the host for the cercaria stage of the Digenea, conditions encourage this possible larval adaptation to persist for a longer period. Whichever way the characteristic cercaria tail is interpreted, there can be little doubt that the presence of a tetraphyllidean type of adhesive organ on the scolex, occurring at a stage shown to be much telescoped in other cestode life-histories, must be further evidence of the tetraphyllidean origin of the Cyclophyllidea.

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Spawning Catfish with Mammalian Hormones

WE have already reported[1] that the catfish (*Heteropneustes*, *Clarias*) available locally respond to large doses of mammalian chorionic gonadotrophins ('Physex': Dumex; 'Antuitrin *S*': Parke, Davis), yielding viable eggs hatching into fry. Having tried the other mammalian hormones available, we wish to record the reactions of catfish not only to them but also to the same hormones used in combination with a threshold dose (*vide infra*) of catfish pituitary gland. In discussing the action of mammalian hormones, Hoar[2] stated that ". . . fish are so unresponsive to many mammalian (and bird) preparations that it is generally impractical to use them. The fish culturist or physiologist who wishes to hasten gonad development in fish is advised to use fish pituitaries". However, Kirshenblat[3] secured viable eggs of *Misgurnus* using methyl testosterone, progesterone and deoxycorticosterone acetate.

Heteropneustes (*Saccobranchus*) usually breeds during July–September, the monsoon months in South India. During February and March, growing ova are noticed in them and the ovary is in stage 4 according to the international maturity scale. We have found that a homoplastic parenteral injection of a dose equal to one-eighth of a gravid pituitary gland does not affect the ovary greatly; the catfish do not spawn and on stripping they yield few ripe eggs. This, therefore, may be taken as a dose to prime the ovary and used as the threshold dose to study the synergic action of the mammalian hormones injected into catfish. A homoplastic injection of a quarter gland of *Heteropneustes* pituitary makes them yield a large number of ripe eggs.

Mammalian follicle-stimulating and luteinizing hormones (Armour Laboratories, Chicago) have caused *Heteropneustes* to spawn and yield a large number of viable eggs[4]. The response of the fish to the follicle-stimulating hormone is obviously due to the small amount of luteinizing hormone present in it; this was afterwards confirmed by Dr. I. Bunding (Armour Laboratories, Chicago). He also stated (*in lit.*) that American minnows could not be made to spawn with similar mammalian gonadotrophic hormones sent to us. Hasler and Meyer[5] also failed to cause goldfish to spawn with purified mammalian luteinizing hormone; the fish also proved refractory, at certain dosage levels, to some mammalian pituitary suspensions[6]. Pregnant mare serum ('Antex': Dumex), œstrogen and progesterone have failed to make catfish spawn[1] and we have now found that methyl testosterone (Boots; 'Perandren' linguets: Ciba), deoxycorticosterone acetate ('Corlin': Glaxo), adrenocorticotropic hormone ('Adrenomone': Armour), growth hormone ('Somar': Armour) and oxytocin (Parke, Davis) are also ineffective in ripening the eggs of *Heteropneustes*. Kawamoto[7] tried unsuccessfully to obtain viable eggs from *Ctenopharyngodon* using sex hormones. On the other hand, catfish receiving a 2·5-mgm. dose of thyroid-stimulating hormone (Armour Laboratories) yielded viable eggs on stripping. This is probably the first instance where the thyroid-stimulating hormone has been used successfully for ripening fish ova. Pickford[8] indicated that thyroid activity may be necessary for gonad maturation, but there is no reference, so far as we are aware, to the use of thyroid-stimulating hormone as an ovulating agent.

We have therefore tried the other mammalian hormones in combination with a threshold dose of *Heteropneustes* pituitary gland. When gravid catfish are injected with a threshold dose equal to one-eighth of a pituitary gland combined with growth hormone, œstradiol dipropionate ('Ovocyclin *P*': Ciba), progesterone ('Proluton': Schering) and methyl testosterone respectively, the test animals gave many ripe and a large number of over-ripe eggs when stripped. Test animals receiving pregnant mare serum (75 I.U.), adrenocorticotropic hormone (10 U.S.P. units) and oxytocin (5 I.U.) respectively in combination with the threshold dose did not yield ripe eggs.

Two important points emerge from our bioassays. First, thyroid-stimulating hormone has been found to be an ovulating agent. Secondly, growth hormone, œstrogen, androgen and progesterone act as synergic agents when used along with a threshold dose of catfish pituitary gland, whereas pregnant mare serum, adrenocorticotropic hormone and oxytocin are ineffective.

Details of these experiments will be published in the *Journal of Scientific and Industrial Research*, New Delhi.

We wish to thank Prof. B. R. Seshachar for encouragement; Dr. I. Bunding (Armour Laboratories, Chicago) and Ciba Pharma Private Ltd., Bombay, for generous help with mammalian hormones and one of us (A. B. L.) is indebted to the Council of Scientific and Industrial Research, New Delhi, for the award of a scholarship.

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A Lungfish (*Protopterus*) from the Middle Zambezi

THE Joint Fisheries Research Organization has been so fortunate as to acquire a lungfish from the Middle Zambezi. The specimen came, on May 15, 1957, from a stagnant 'backwater' of the Zambezi, at that time receding from its peak flood, in the Chipepo district on the northern bank, and was collected by Mr. Thayer E. Scudder, an anthropologist, who was at the time studying the local Gwembe Tonga people. Notwithstanding the fact that several fish-collecting expeditions have been made to this area, which is due shortly to be flooded by the waters of the Kariba dam, no other specimens are known from this region. However, it is known to the natives, who call it 'Ikana'. The fish is a specimen of *Protopterus annectens* (Owen), typically light-coloured ventrally, with the belly and lower head covered with conspicuous dark spots, and is of considerable interest in many respects.

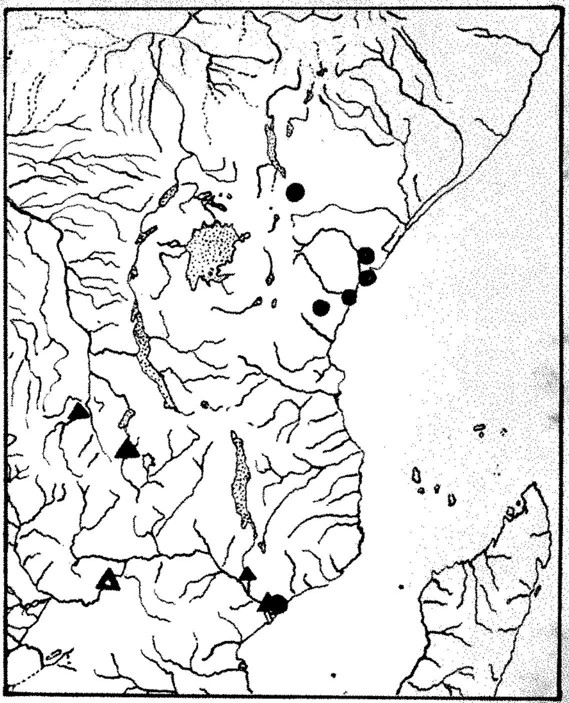

Fig. 1. Sketch map illustrating recorded occurrence of *Protopterus annectens* (▲), and *P. amphibius* (●), in East Africa and the Zambezi and Congo Basins. The locality of the new record is indicated by an open triangle (after Trewavas, ref. 1)

This is the first record of a lungfish from the Middle Zambezi system, which is faunistically divided from the Upper Zambezi by the Victoria Falls and the Lower Zambezi by the Kebrabassa rapids, so that each section of this great river has a characteristic fish-fauna. The Middle Zambezi may in general be regarded as intermediate in that, while it has itself few distinct species, the characteristic fishes of the Upper Zambezi, such as *Hemichromis fasciatus*, *Sarcodaces odoë*, *Tilapia macrochir*, etc., derived presumably from the Congo, and those occurring in the Lower Zambezi such as certain chondrichthyans, gobiids, ambassids, syngnathids, etc., which are derived from marine or estuarine faunas, are alike absent from it. Lungfishes have still not [illegible] been recorded from the Upper Zambezi, though enough circumstantial evidence exists to make their occurrence there probable.

Secondly, the locality of this specimen is intermediate between known records for *P. annectens* from the Lower Zambezi and the Lower Shire on one hand, and Katanga and the Lower Luapula on the other[1]. The present record is marked on the map of Fig. 1 as an open triangle.

A radiograph of the specimen revealed a third point of interest, namely, that it has only 32 pairs of ribs. According to Trewavas's recent study[1], it resembles in this respect a specimen from the Lower Shire (33 pairs) and Katanga specimens (32–33 pairs), while West African specimens have 34–37 pairs. Trewavas reasserts the specific distinctness of *Protopterus amphibius* (Peters), based on studies of material from Kenya darker, more thickset and with fewer ribs (27–29 pairs) than *P. annectens*. While the specific distinctness of this material is not to be doubted, the specific name *amphibius* was originally proposed by Peters[2] (*Rhinocryptis amphibia*) for specimens collected from Quelimane. Most of these have since proved to be *P. annectens*, and while one cannot as yet be certain on this point, it seems at present difficult to believe that there are two species of *Protopterus* in the Zambezi delta as maintained by Schneider[3]. There the species is based on one specimen stated to have 30 pairs of ribs, a number greater than that found in the Kenya specimens, and

Table 1

Total length (mm.)	278	Pelvic fin length (mm.)	76
Snout-vent length (mm.)	145	Pectoral fin-membrane width (mm.)	1·5
Snout-dorsal fin length (mm.)	77	No. of external gills	3
Head length (tip of snout to top of gill-opening) (mm.)	42	Longest gill, length (mm.)	15
Head-width (mm.)	30	No. of scales (gill-opening to pectoral fin)	46
[illegible]oral fin length (mm.)	92		

approaching the number so far known for *P. annectens*. Furthermore, the locality for the Quelimane specimen (see map) appears very isolated from the other recorded localities of *P. amphibius*.

My thanks are due to Mr. T. E. Scudder for collecting and preserving this specimen, to Mr. M. A. E. Mortimer of the Department of Game and Tsetse Control, Northern Rhodesia, for presenting the specimen to our collection, and to Dr. A. C. Ellis of the Federal Health Service, Fort Rosebery, for arranging for the radiograph to be made of it.

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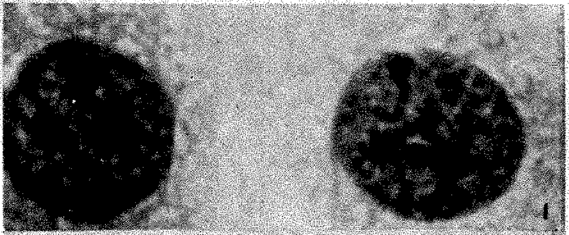
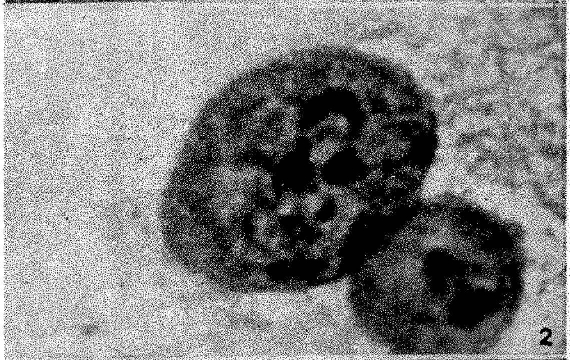
Representation of the X Chromosome in Intermitotic Nuclei in Man

IT is generally supposed[1] that there is a close relationship between the sex chromosomes and the nucleoli in most species, though the evidence for this in mammals is scanty[2]. It is nearly certain that the sex chromatin body[3] found in most nuclei in females of some species, including man, represents the heterochromatin of the *X* chromosome pair[4]. The demonstration of a persistent connexion between these bodies in some nuclei may serve to support both hypotheses. Reitalu[5] has described such a connexion in human fœtal liver; the matter seems important enough to justify this further description, based on observations, made in ignorance of Reitalu's, of similar structures seen elsewhere.

Thyroid tissue cultures offer exceptionally favourable material for the study of nuclear detail. We have used the primary outgrowths from fragments of human thyroid removed at operation, attaching the fragments to coverslips with plasma clot. In such preparations mitoses are rare, and most of the cells seen appear to be epithelial migrants from the original explant. Sex chromatin may be seen in as many as 90 per cent of nuclei. The nucleolar chromocentres are large and variable in number as well as size, though two is the commonest number. A well-defined strand of chromatin joining the sex chromatin to these chromocentres (Figs. 1, 2) is seen in perhaps 1 per cent of the cells. It is usually sinuous in its course and may bear one or two small chromatin granules; we have not been able to satisfy ourselves that it is clearly double in the manner of Reitalu's drawings. It is demonstrable only with difficulty in other material, but Fig. 3 shows a very clear example in a decidual cell from an abortion. Klinger's[6] illustrations (especially his Fig. 7) suggest that similar threads might be demonstrated in human amnion or chorion.

Reitalu describes this strand as a euchromatin thread joining two heterochromatin bodies. The heterochromatin of the sex chromatin must lie in the unpaired segment of the *X* chromosomes. We have failed to demonstrate any sex difference in the nucleolar chromocentres in several tissues, and conclude that they probably represent heterochromatin of the paired segment. These three linked structures must therefore represent a substantial part of the *X* chromosome, visible in the resting nucleus.





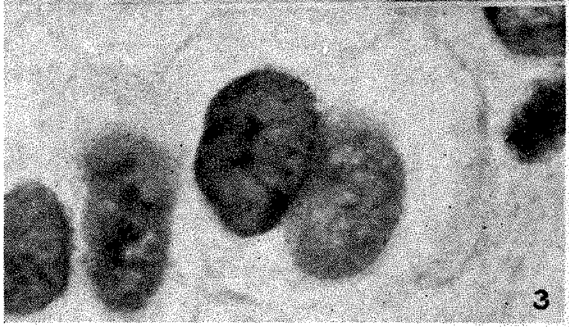


Fig. 1. Two nuclei from a thyroid tissue culture (female). On the left, the euchromatin thread is seen as a thick relatively ill-defined strand running down and to the right from the sex chromatin (at 12 o'clock) to join the right hand of the two nucleolar chromocentres. On the right, the euchromatin thread is very well defined, though its last part is out of focus: it runs from the sex chromatin (at 12 o'clock) to the left hand of the three nucleolar chromocentres. (Cresyl echt violet, × 2,000)

Fig. 2. An unusually fine and well-defined euchromatin thread, running from the sex chromatin (at 3 o'clock) straight to the nearest of the three nucleolar chromocentres. (Feulgen, × 2,000)

Fig. 3. Decidua from an abortion. A well-defined euchromatin thread running from the sex chromatin (at 4 o'clock on the nucleus of the central cell) to the nearest chromocentre. (Feulgen, × 2,000)

One of us (D. M. S.) acknowledges with thanks a grant from the Friends of the Hebrew University of Jerusalem.

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Evapo-transpiration from Different Crops exposed to the Same Weather

PENMAN[1] has concluded from a physical analysis of the process of evaporation that the rate of evapo-transpiration is the same for different crops exposed to the same weather provided that each crop covers the ground completely and is approximately of the same colour. Rider[2], however, has concluded from microclimatic measurements made above extensive areas of different crops that these can so modify the effective weather that large differences in the water loss from different crops can occur.

Table 1. ENERGY BALANCE, WELLESBOURNE (JUNE 6–OCTOBER 1, 1957)
Energy expressed as in. of water (1 in. = 1,500 gm.cal.)

Measurement	Method	Grass Daily irrigation	Grass Rain only	Carrots Daily irrigation	Carrots Rain only	Open water surface
Short-wave sun and sky radiation	Measured by Kipp solarimeter	18·54	18·54	18·54	18·54	18·54
Heat storage change	Calculated from temperature and moisture measurements	0·16	0·18	0·14	0·16	0·24
Long-wave radiation	Calculated from temperature, humidity and hours of sun	5·34	5·34	5·34	5·34	5·34
Albedo	Calculated from measurements of visible albedo with infra-red albedo taken as 45 per cent	5·56	5·56	4·64	4·64	1·11
Growth	Calculated from measurements of dry weight and energy equivalent	0·10	0·07	0·38	0·17	0·00
Evapo-transpiration	Measured (see text)	9·04	5·89	12·88	7·65	8·82
Heat transfer: from air to crop	Calculated by subtraction	1·34	—	4·56	—	—
,, from crop to air		—	1·86	—	0·90	3·51

The evapo-transpiration from grass and carrots was measured at the crop weather station, Wellesbourne[3], continuously from mid-June until early October 1957 in the centre of plots 600 square yards in area. There were two soil-moisture treatments; in one the plants were irrigated each day to restore the soil to field capacity and in the other the plots received only rainfall. Each measurement was based on the mean of the readings from three similar lysimeters. The lysimeters used to measure evapo-transpiration in the plots supplied by rainfall only consisted of weighable monolith soil cores, whereas for the plots irrigated daily, drainage lysimeters[4] were used. The twelve lysimeters were buried to their rims and completely surrounded by plants which received the same soil-moisture treatment and were similar in size to those growing in the lysimeters. The instruments were tested before and after use and found to be water-tight.

Fig. 1 shows the measured cumulative evapo-transpiration from the grass and carrot crops plotted against the measured cumulative evaporation from a standard evaporation tank. The relation was linear in each case. The use of the evaporation tank readings as an index of the evaporative conditions is supported by the close agreement between the measured evaporation and that estimated by Penman's method[1].

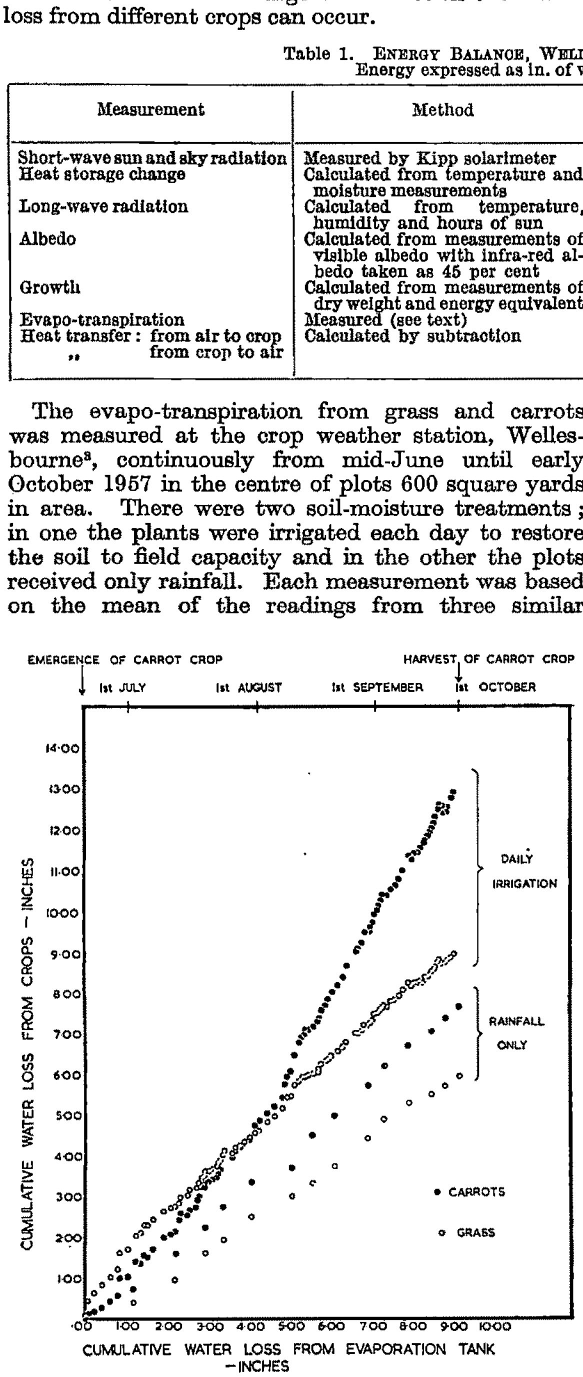

Fig. 1. Effect of crop type and soil moisture treatment on relative rate of evapo-transpiration

After the irrigated carrots had covered 40 per cent of the ground surface there was an alteration in the slope of the linear relation between evapo-transpiration from the crop and evaporation from the water tank (top line, Fig. 1), and further increases in crop cover and height had no effect on the rate of evapo-transpiration. With both grass and carrots receiving only rainfall the rate of evapo-transpiration was reduced by 40 per cent as compared with those that were irrigated.

Meteorological observations enabled the energy balance to be calculated for the grass and carrot crops grown under the two soil-moisture treatments and for the open water surface of the evaporation tank.

The differences in the amount of evapo-transpiration from the two crops could not be explained by the differences in the amount of energy used for growth, heat storage or for reflexion, so that large differences must have occurred in the amount of heat transferred to and from the air.

Similar comparisons are now being made with other vegetable crops in order that the relation between evapo-transpiration and evaporation from an open water surface may be established for crops usually irrigated.

Grateful acknowledgment is made to Miss J. I. E. Rubio for taking most of the measurements.

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A Genetic Test for Side-chains in a Phage Chromosome

A NUMBER of authors[1] have proposed side-chain models of the chromosome. The chromosome, as suggested most recently by Taylor, consists of a double core or central backbone, with double deoxyribonucleic acid helices[2] attached at right angles. These double helices are connected to the core at specific attachment points so that one polynucleotide chain of each helix is attached to one half of the core and the other polynucleotide chain to the other half.

This side-chain model is of interest for a number of reasons. (1) Its double structure is compatible with the organization and duplication of chromosomes as revealed by the studies of Taylor, Woods and Hughes[3] using tritium-labelled thymidine. (2) Despite the calculations of Levinthal and Crane[4] suggesting the feasibility of unwinding long double deoxyribonucleic acid helices, unwinding and separation of relatively short deoxyribonucleic acid helices arranged as side-chains is more easily visualized. (3) Conventional crossing-over would take place along the central backbone, and additional recombinations could occur on the side-chains. (4) Negative interference and gene conversion can be explained in at least a formal manner by side-chains.

We have found no evidence for side-chains using a genetic test on bacteriophage *P*22 of *Salmonella typhimurium*. The test could detect the occurrence of two loci on the same side-chain. The only requirement of the test is the presence of marker loci to either side of the two loci to be tested. The test is of general applicability and can be used with other organisms.

The wild type of *Salmonella typhimurium* phage *P*22 is temperate. On infection, some bacteria may be lysed, but some may survive and give rise to lysogenic progeny. Lysogenic bacteria possess the ability to produce the infecting phage and are immune to subsequent infection by the phage or its mutants. Genetic control of the lysogenic condition lies in the prophage, which is presumed to be phage genetic material attached to the bacterial chromosome. Temperate phage *P*22 produces plaques with turbid centres owing to the growth of lysogenic bacteria.

Phage *P*22 mutates spontaneously to forms which produce plaques with clear centres. All mutants forming clear plaques can be classified into one of three phenotypic groups based on their ability to lysogenize[5]. These groups are called c_1, c_2 and c_3. The *c* mutations can be mapped genetically as three closely linked pseudoallelic series[6]. All the c_1 mutations fall in one series, all the c_2 mutations in a second, and all the c_3 mutations in a third. The mutations of each series are separable by recombination. These pseudo-allelic series behave like the functional units or cistrons of Benzer[7]. The alleles of the different series interact to give lysogeny, whereas the alleles of the same series do not. The *c* region is flanked by plaque-morphology loci. Fig. 1 summarizes the above in a linkage map. More complete descriptions of phage *P*22, its mutants and the methods and media used in their handling have been published elsewhere[5].

The *c* region was studied for evidence of side-chains. *Salmonella typhimurium* of strain *LT*2 is grown to concentrations of about 10^8 cells/ml. in *L* broth. The cells are washed twice in buffered saline, resuspended in one-half the original volume and aerated for 45 min. at 37°. The cell concentration is then re-adjusted to 1×10^8 cells/ml. with buffered saline. Mixtures of *c* mutant stocks, one marked with plaque morphology mutations m_3 and h_{21} and the other with the wild-type alleles of these mutations, are submitted to adsorption for 5 min. A 1 : 10 dilution is made into *L* broth containing a concentration of anti-phage serum sufficient to inactivate 99 per cent of the unadsorbed phage in 5 min. Further dilutions are then made, and after 90 min. chloroform is added to kill any surviving bacteria. Diluted samples of phage progeny are plated on indicator agar for examination.

Only the rare turbid recombinants arising by a recombination between the closely linked *c* loci in region II (Fig. 2) need be considered. (The reciprocal double-mutant recombinants are not easily detected.) These turbid recombinants are examined for additional recombinations between the clear-plaque region and the m_3 locus to the left (region I, approximately 13 units long) and the h_{21} locus to the right (region III, approximately 7 units long). Four classes of turbid recombinants are expected. Based on the relative frequencies of these four classes, a distinction between a linear vs. side-chain model can be made.

Assuming a linear structure, the four classes in order of decreasing frequencies are as listed in Fig. 2*a*. The same four classes are expected, but with different

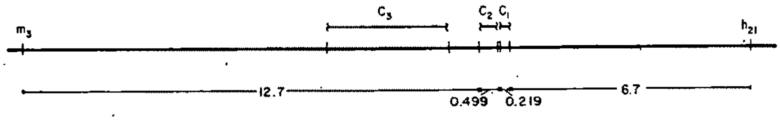

Fig. 1. Linkage map for phage *P*22

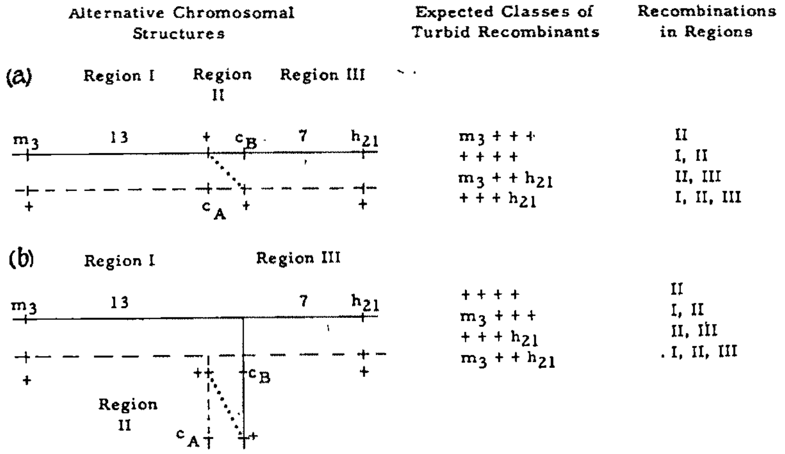

Fig. 2. Alternative chromosomal arrangements of the phage *P*22 linkage map and the expected turbid recombinant classes. The dotted lines indicate the recombinations giving rise to turbid progeny

frequencies, if the *c* alleles are arranged on the same side-chain as shown in Fig. 2*b*. (Still different but distinctive frequencies of these four classes are expected should the order of the *c* alleles be reversed.)

The rather unlikely possibility that both the c_1 and c_2 cistrons are on the same side-chain was tested by the intercistron cross, $c_2^5 \times c_1^{49}$ (Table 1). The results are in agreement with the linear model: the m_3+++ class is the major class. The two most distantly linked mutant c_2 stocks c_2^5 and c_2^{27} were crossed, on the assumption that a side-chain can be equated to an entire cistron. Again the results are in agreement with a linear structure. Similar findings were obtained from crosses between more closely linked c_2 mutants (Table 1). Finally, crosses between alleles of the smaller c_1 cistron also support the linear model (Table 1).

Table 1. CROSSES BETWEEN *C* MUTANTS OF PHAGE *P*22

Crosses		Map distance between *c* mutations	Frequency of turbid recombinant classes (per cent)				Total turbid progeny
++ Parent	m_3h_{21} Parent		m_3+++	++++	m_3++h_{21}	+++h_{21}	
c_2^5	c_1^{49}	0·843	49·3	23·8	19·5	7·4	231*
c_2^5	c_2^{27}	0·499	47·8	20·5	23·6	8·1	395†
c_2^{23}	c_2^{27}	0·333	44·8	20·2	27·0	8·0	163
c_2^5	c_2^{23}	0·276	40·8	23·9	25·4	9·9	142
c_1^{45}	c_1^{52}	0·219	55·6	18·8	17·9	7·7	117*
c_1^{65}	c_1^{49}	0·149	58·8	17·8	16·1	7·3	124*

* Sum of two independent experiments.
† Sum of three independent experiments.

The results presented do not support the idea of two genes on the same side-chain. Conceivably, some support for this hypothesis might be forthcoming from crosses between more closely linked alleles than those mentioned above. Crosses between alleles as close as 0·067 map unit suggest that linearity is still the rule. The alternative hypothesis of individual loci on individual side-chains, while not ruled out by these experiments, seems improbable. The expectation that the double-recombinant classes would increase with decreasing distance between alleles is not borne out by the results.

The apparent lack of side-chains in a phage should not be taken as too damaging to the model. A most attractive aspect of Taylor's model is the possibility that prophage establishment is the attachment of phage deoxyribonucleic acid as a side-chain to open specific points on the bacterial chromosome.

This investigation was carried out at Brookhaven National Laboratory under the auspices of the U.S. Atomic Energy Commission.

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Analysis of Mixtures of Glucosamine and Galactosamine with Bakers' Yeast

STUDIES in this laboratory on the incorporation of carbon-14 precursors into corneal mucopolysaccharides necessitated the development of a method for the quantitative separation of labelled hexosamines in tissue hydrolysates. Other procedures[1-3] employing column chromatography for quantitative resolution were not suitable for the analysis of large numbers of samples. The specific fermentation by bakers' yeast of D-glucose but not D-galactose[4] and the reported phosphorylation of D-glucosamine by yeast hexokinase[5] suggested the possibility of employing whole bakers' yeast for the separation of the naturally occurring amino-sugars, D-glucosamine and D-galactosamine. Experiments with bakers' yeast revealed a quantitative removal of D-glucosamine, as measured by colorimetric procedures, and no detectable utilization of D-galactosamine. In the present communication, we wish to describe a procedure for quantitative analysis of mixtures of these two sugars. Slein[6] has reported the use of purified yeast hexokinase to distinguish between these hexosamines.

Tissue hydrolysates are first adsorbed and eluted from 'Dowex 50' (H+) resin columns in order to separate the amino-sugars from other carbohydrate components. The total hexosamine content is determined on an aliquot of these preparations by the Blix–Elson–Morgan procedure[7,8]. Another aliquot, containing up to 1 μmole of glucosamine, is placed in a volume of 1·5 ml. of water in a 25-ml. Erlenmeyer flask. 2 ml. of a yeast suspension (600 mgm. wet weight) is then added to each flask. The suspension is prepared by washing 15 gm. of *fresh* bakers' yeast (Fleischmann) four times with distilled water, with centrifugation at 4° C. between each washing. The yeast is suspended uniformly in 25 ml. of 0·1 *M* sodium phosphate buffer (*p*H 7·5) and brought to a volume of 50 ml. with water.

The stoppered flasks are incubated for 1 hr. in a constant-temperature shaker at 30° C. and 70 oscillations per min. After removing the yeast by centrifugation at 4° C., 1 ml. aliquots of the supernatant fluids are analysed for hexosamine. Centrifugation was usually repeated to ensure complete removal of the yeast. With each yeast run, a galactosamine standard (for example, 0·9 μmole) plus yeast is included in duplicate to correct for any losses by evaporation, for effects of phosphate on the colorimetric determination, and for possible non-equilibration with the large volume of yeast cells. A yeast control, which gives an optical density less than 0·01, and a glucosamine control (1 μmole) plus yeast also are included to ensure that there is complete removal of the glucosamine. More than 99 per cent of the glucosamine was removed with four different batches of fresh bakers' yeast. The commercial yeast is stable for several weeks when stored at 4° C.

The galactosamine content is calculated, employing the internal galactosamine standard, from the hexosamine concentration after yeast action. It is assumed that the extinction coefficients of glucosamine and galactosamine in the Blix test are identical[9,10]. The glucosamine content is calculated as the difference in hexosamine concentration before and after yeast action. Results of several analyses of synthetic mixtures and a comparative analysis of four blood group substances, kindly supplied by Dr. E. A. Kabat, are listed in Table 1. The limiting factor in the

Table 1. Analysis of Synthetic Mixtures of Amino-sugars and Blood-Group Substances

Added		Found	
Glucosamine (per cent)	Galactosamine (per cent)	Glucosamine (per cent)	Galactosamine (per cent)
0	100	0*	100*
50	50	50	50
76	24	74	26
20	80	21	79
37	63	35,35*	65,65*

Blood-group substances	Analysis by Leskowitz and Kabat (ref. 2)		Found*	
Hog, 16	57	43	58,57	42,43
Horse, 6–15 per cent	69	31	67	33
Saliva, W.H., 2–10 per cent	61	39	55	45
Horse, 5–25 per cent	53	47	45	55

* Samples were purified by adsorption on a 10-ml. column of 'Dowex 50' cation exchange resin (200–400 mesh, 12 per cent cross-linkage, H^+ form). The amino-sugars were completely adsorbed when placed on such columns in 2 ml. of 2 *N* hydrochloric acid. After washing the columns with water, the hexosamines were eluted with about 25 ml. of 0·75 *N* hydrochloric acid and lyophilized over silica gel–sodium hydroxide. The procedures described by Boas (ref. 8) and Roseman and Daffner (ref. 10) also should be adequate for this purpose. The blood group substances and the galactosamine sample initially were hydrolysed for 2 hr. in 2 *N* hydrochloric acid in a boiling-water bath

precision of the method apparently is the reproducibility of the Blix test. As a matter of routine, total hexosamines are determined in triplicate, and two aliquots of each sample are incubated with yeast and analysed in duplicate. 2–4 μmoles of total hexosamine (0·43–0·86 mgm. of the hydrochlorides) usually are sufficient for a complete analysis of each sample. This varies, of course, with the relative composition of the unknowns.

We wish to express our appreciation to Dr. Herbert J. Rapp for suggesting the use of a micro-organism for this separation. The work was supported by a Fight for Sight grant of the National Council to Combat Blindness, Inc., New York, and by grant *B*–141 of the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service.

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Contact Angles and Work of Adhesion

Because of frequent misunderstandings, we would like to emphasize that the work of adhesion W_{SL} in the equation,

$$W_{SL} = \gamma_L(1 + \cos\theta) \qquad (1)$$

which one of us has recently pleaded[1] should be called Young's equation, is the reversible work required, per square centimetre, to separate the liquid from the solid, leaving an adsorbed film in equilibrium with the saturated vapour of the liquid on the surface of the solid. This work is less than the work W_{SLO} required to separate the liquid from the solid, leaving a clean surface free from adsorbed vapour, by π_{SV^0}, the surface pressure of the adsorbed film of vapour on the solid. Calling W_{SL} in (1), W_{SLV^0}, to indicate the presence of the adsorbed film of saturated vapour,

$$W_{SLO} = W_{SLV^0} + \pi_{SV^0} \qquad (2)$$

Harkins and Livingston's remark[2] that "it is extremely unfortunate that this equation came into notice at all" was made because Harkins had previously used W_{AB} for the work required to separate two liquids A and B, with clean surfaces and surface tensions undiminished by surface films of the other liquid. Later in the same paper[3] Harkins and Livingston stated that equation (1) is correct provided that W_{SL} means W_{SLV^0}, not W_{SLO}. The importance of the adsorbed film of vapour for the magnitude of the work of adhesion is usually greater for solid–liquid than for liquid–liquid systems; and attention has frequently been directed to it, first by Harkins and Dahlstrom[4], later by Bangham and Razouk[5], Harkins and Livingston[3], and by others.

π_{SV^0}, the difference between the work of adhesion to the clean and to the film-covered surface, cannot be measured directly; but π_{SV^0} can be calculated if the adsorption isotherm of the vapour on the solid can be measured. If Γ is the amount adsorbed when the pressure of the vapour of the liquid is p, the Gibbs adsorption equation,

$$\Gamma = \partial\pi / RT\partial\ln p \qquad (3)$$

can be integrated to

$$\pi_{SV^0} = RT\int_0^{p^0}\Gamma d\ln p \qquad (4)$$

as was shown by Bangham and Fakhoury[6], and Bangham[7]; p^0 is the saturated vapour pressure of the liquid.

W_{SLV^0} is probably the work of adhesion of greatest practical importance and is by far the easiest to measure, since the part of the solid surface of importance for determining the contact angle is that immediately adjacent to the edge of the liquid, and must therefore be in equilibrium with vapour which is saturated, or nearly saturated. If W_{SLO}, which may be of greater theoretical interest, is required, the amount Γ adsorbed at a series of pressures of the vapour of the liquid must be measured and equations (2) and (4) used. On surfaces smooth enough to permit easy measurement of the contact angle, however, Γ will be so small that its measurement will usually be difficult.

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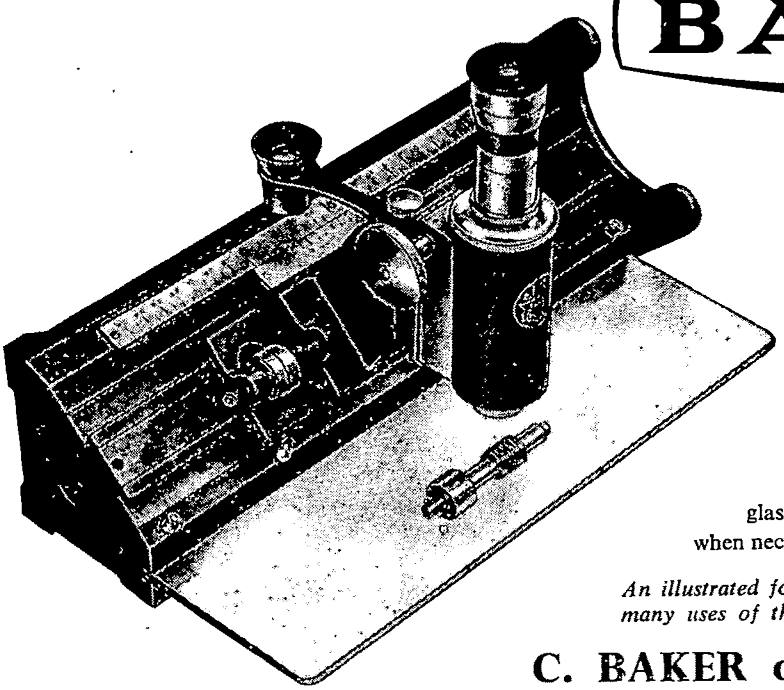

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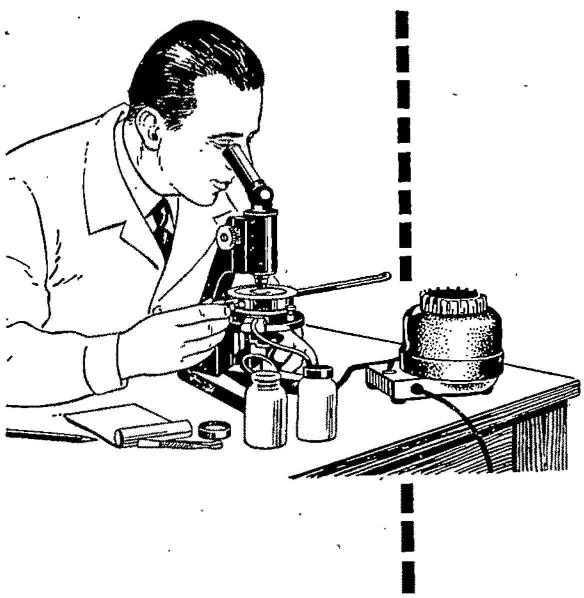

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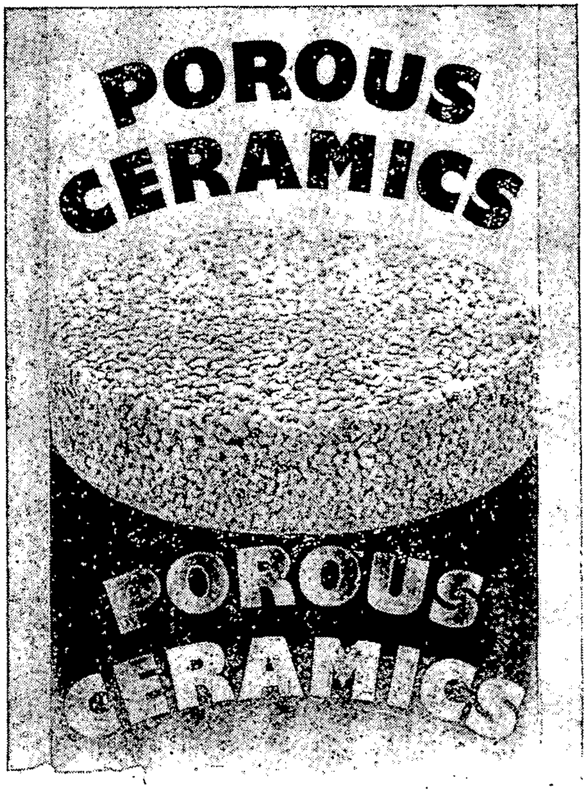

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A Sensitive Micro-Spectrophotometric Method for Succinate Analysis

Assay of succinic acid by estimation of reduction of a redox dye in a succinic dehydrogenase and cyanide-poisoned system has been reported by Lardy[1] for methylene blue, and by Vishniac and Ochoa[2] for 2,6-dichloroindophenol. The disadvantage to the use of these dyes is that they are non-enzymatically reoxidized directly by oxygen and there is uncertainty concerning the end-point of the reduction of the dye and thus about the amount of succinate oxidized.

In our experiments air was displaced with argon in the solutions used and in the ground-glass stoppered Beckman cells employed. The cells were charged in an argon atmosphere in an open-top rectangular jar.

A 20 per cent succinoxidase[3] suspension which was quite stable in ice for several hours was prepared with 0·1 M phosphate buffer (pH 7·4) and homogenized in ice (using a low-speed drill press) for 7 min. with a 'Teflon' pestle glass homogenizer. This homogenization time of 7 min. was found to be the best of many intervals tested in order that sedimentation effects of tissue particles in the Beckman cells be minimized.

Each Beckman cell, including the 'blank' cell, contained 0·1 ml. 20 per cent tissue suspension (0·67 per cent after dilution in cell), 0·3 ml. 0·1 M potassium phosphate buffer (pH 7·4), 0·1 ml. 0·05 M potassium cyanide, 0·5 ml. 0·01 per cent, 2,6-dichloroindophenol dihydrated sodium salt, and 1·8 ml. glass-distilled water. It was found that the 0·67 per cent tissue suspension used in the Beckman cell media was preferable to the 2 per cent suspension used by Umbreit[3] for manometric analyses, because of both optical considerations and difficulties incurred with reduction of the dye by endogenous substrate in the succinoxidase preparation. Beckman readings showed that the endogenous reactions went to completion in about 6 min. At this point a further addition of 0·2 ml. of water was made to the 'blank' cell, and 0·2 ml. of 5×10^{-4} M sodium succinate solution (or any unknown solution) was added to all other cells. The 'blank' cell was adjusted to a high enough scale reading so that negative readings need not be taken on the other cells.

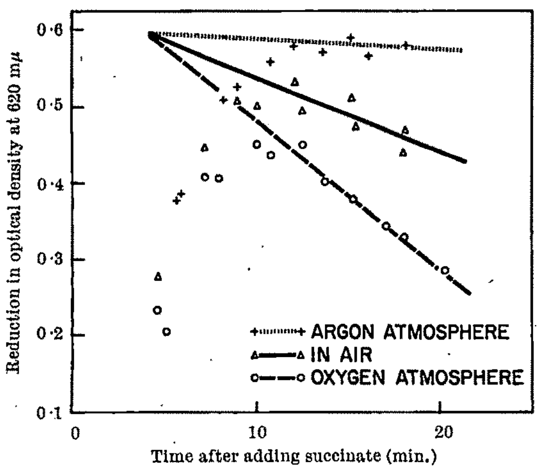

Fig. 1. Decreases in density relative to the 'blank' cell during the stated periods of incubation in systems varying from 0 to 100 per cent saturation with oxygen. The straight lines coming to a common point represent extrapolation of the slopes of the three curves

The relative effects of atmospheres of argon, air and oxygen on changes in optical density after addition of the stated amount of sodium succinate in each system are compared in Fig. 1. The Beckman density readings refer to relative decreases in density from the 'blank' cell. It is clear from these comparisons that by substituting argon for oxygen, reversal of the reduction of the dye through direct re-oxidation is avoided, and a more valid measurement of succinate content thus achieved. By extrapolating the slopes of the three curves in Fig. 1, and observing a common point of intersection, one again may see the desirability of working in the anaerobic system described in order to achieve maximum effects. The sensitivity of the argon system is such that each 0·01 Beckman density unit is proportional to 0·00167 μmole of succinate. Accuracy to the nearest 0·01 μmole of succinate may thus be achieved.

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Formation of Carbon by Decomposition of Carbon Suboxide at 750-780° C.

The recent communication by Deitz and Prosen[1], which suggests that carbon suboxide is the means of transport of carbon in the system carbon monoxide–graphite at 450° C., prompts us to record some observations on the decomposition of carbon suboxide.

During attempts to prepare carbon suboxide by the pyrolysis of diacetyl tartaric anhydride[2] at 750–780° C., the formation of lustrous flakes was observed in the hot part of the reactor. This material was probably formed by polymerization of carbon suboxide, followed by decomposition of the polymer[3].

These lustrous flakes (0·5 per cent w/w of the diacetyl tartaric anhydride initially present) were shown by chemical and spectrochemical analyses to be essentially carbon, with about 1 per cent of hydrogen and of oxygen; trace impurities (silicon, aluminium, iron and magnesium) were present. A Debye–Scherrer X-ray diffractogram showed a strong 002 band and weak 100 and 110 bands. The optical reflectance measured in cedar wood oil was 18 per cent, a value higher than that (about 11 per cent[4]) reported for natural graphite.

It is noteworthy that instead of a soot, a hard graphite-like material was deposited at these low temperatures.

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Wave-length Effect in Flash Photolysis

When oxygen-free solutions of methylene blue or thionine in dilute sulphuric acid are subjected to flash photolysis using orange-red light filtered from a krypton- or xenon-filled flash-tube, reversible bleaching of the dyestuffs occurs. The bleaching is accompanied by increased absorption in the region 360–440 mμ where the dyestuffs themselves absorb very weakly. The transient species responsible for this absorption have the appearance of being triplet levels of the dyestuffs, disappearing with life-times of less than 30 μsec. The same species are also produced when the light of the flash is filtered through Chance *OX*7 glass (transmission approximately 250–390 mμ).

When the unfiltered light from the flash-tube is used for excitation, there are formed, in addition to the 'triplet' species, other species which disappear much more slowly (half-life of the order 0·5 msec. under the conditions of experiment). From the limited information at present available, the second type of species appears to be similar to the semiquinones which are formed by reduction of the dyestuffs when their solutions are flashed with orange-red light in the presence of 0·1 *M* ferrous sulphate (in the presence of the ferrous sulphate the 'triplet' species are no longer evident). If the long-lived species are indeed the semiquinones of the dyestuffs, it would appear that water itself can act as the reducing agent when short wave-length ultra-violet light is used for excitation.

Whatever the true nature of the long-lived and the short-lived species, they are formed by independent processes, the long-lived species by wave-lengths shorter than 250 mμ and the short-lived species by longer wave-lengths. These observations may be compared with the results obtained by Bridge and Porter[1] in the flash photolysis of solutions of duroquinone using the full light of the flash-tube. They observed the independent formation of both triplet and semiquinone radical, and it is interesting to speculate whether their results can be explained in terms of a similar wave-length effect, since many of the solvents they used are transparent to wave-lengths shorter than 250 mμ. Before the behaviour of duroquinone can be fully established, therefore, it would be necessary to carry out experiments with filtered exciting light. This same precaution naturally applies to all flash-photolysis work, and is of course particularly important in those investigations where photosensitization to daylight is in question.

The investigation of the effects observed with methylene blue and thionine is being continued and will be reported in detail elsewhere.

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The fact that primary photochemical processes may depend on wave-length is, of course, well known, and investigations of wave-length effects in flash photolysis have previously been carried out[1]. Our work on duroquinone was concerned with the identification of the intermediates and of the kinetics of their reactions, which are, for any given intermediate, independent of wave-length.

A study of the effect of wave-length on the primary products of photolysis of duroquinone is now in progress. Mr. Michael Reed has found that when a glass filter (cut-off at 300 mμ) is used, triplet-state absorption in liquid paraffin and formation of semiquinone radicals in ethanol are still observed, though the concentration of radical is considerably reduced. Some reduction in concentration is to be expected on the basis of reduced light absorption, since the maxima of duroquinone lie at 270 mμ ($\log \varepsilon = 4 \cdot 3$), 340 mμ ($\log \varepsilon = 2 \cdot 3$) and 450 mμ ($\log \varepsilon = 1 \cdot 4$).

If Parker's assignments are confirmed, the methylene blue system provides another example where radical formation does not occur principally via the triplet state. So far as dependence on wave-length is concerned, it will be necessary to have observations on the quantity of light absorbed in each experiment and the effect of intensity, since both wave-lengths and intensity have been varied and the observed differences may be attributed to either.

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A Methane-Conversion Detector for Gas Chromatography

Detectors most commonly found in gas chromatographic instruments involve the use of thermal conductivity cells. Such cells, particularly those of the thermistor type, decrease in sensitivity with increasing temperature. Since it is necessary sometimes to heat the cell to prevent condensation effects of high-boiling materials leaving the chromatographic column, new approaches to this problem were sought. Martin and Smart[1] were successful in improving the sensitivity by converting the resolved compounds as they emerged from the chromatographic column into carbon dioxide and water, and detecting the carbon dioxide by means of an infra-red gas analyser. This procedure was repeated by Green[2] using a thermal conductivity cell to measure the carbon dioxide ; however, loss of resolution and band spreading detracted from the increased sensitivity obtained. Green improved this technique by passing the water formed in the combustion process through a hot tube containing iron powder, thereby producing hydrogen, which was detected in the thermal conductivity cell. Nitrogen was the carrier gas.

The procedure presented here makes use of a small tube containing a 'hydrocracking' catalyst at the exit end of the chromatographic column. As each compound emerges from the column, it is converted to methane and water. The water is removed in a drying column, and the methane is measured by a thermal conductivity cell. Hydrogen is used as the carrier gas.

The methane converter consists of a tube of 'Pyrex' glass, 24 cm. long and 5 mm. in diameter, filled with a nickel catalyst of 30–60 mesh. The tube is kept at about 350–450° C. by means of a heated nichrome coil.

This procedure has the following advantages :

(1) Increased sensitivity is obtained by being able to operate the thermal conductivity cell at ambient temperatures, since only methane is being detected.

(2) Calibrations due to differences in thermal conductivities of the separated components are unnecessary; however, the carbon number effect must be considered.

(3) The method is applicable to other detectors where hydrogen is used as a carrier gas, such as the hydrogen flame detector[3].

(4) It offers a convenient way of analysing aqueous solutions of aldehydes, alcohols and ketones, since these are easily converted to methane and water over the catalyst. The water may be removed by a suitable drying column containing, say, calcium sulphate.

Compounds susceptible of complete 'hydrocracking' to methane have been analysed using hydrogen as the carrier gas. The methane conversion procedure has been used for mixtures containing (*a*) C_1–C_{12} paraffins and olefins, (*b*) C_5–C_8 naphthenes, and (*c*) C_2–C_5 aldehydes, alcohols and ketones. The catalyst remained active for more than 100 samples.

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Contamination of Surfaces by Conductivity Water from Ion-exchange Resins

IN several recent papers research workers in surface chemistry have reported using ion-exchange resins as a convenient means of removing electrolytes—in place of dialysis in the treatment of inorganic sols, for example, and to obtain 'conductivity water' for studies of dilute detergent solutions or monolayers on a Langmuir trough. For most purposes where 'pure' water is needed, even in colloid chemistry, the water obtained by passing ordinary distilled water through a 'mixed-bed' ion-exchange resin column is perfectly satisfactory, but for any critical work in surface chemistry it is not. The dangers are shown by the following experience.

In a study of the surface charge on finely divided particles by the micro-electrophoresis method, water from a mixed-bed resin column was used throughout for washing the cell and preparing the solutions. It had a specific conductivity of 0·3 micromho cm.$^{-1}$ and would normally be considered of good quality compared with ordinary distilled water, which gives about 3·5 and contains traces of copper, etc. A series of determinations with different dilute salt solutions gave what seemed to be satisfactory results until similar measurements were made with dilute hydrochloric acid. As the concentration of hydrochloric acid was increased from 10^{-6} to 10^{-4} *N*, the electro-osmotic flow along the glass walls of the cell fell to zero and then reversed in direction; that is to say, the glass became positively charged. (The suspended particles on the contrary remained negatively charged.) The anomalous charge on the glass was eventually ascribed to contamination by traces of a weakly basic substance from the resin column—almost certainly soluble polymer fragments released from the nitrogenous anion-exchange resin.

The presence of traces of organic impurities in water from resin columns is very difficult to check by direct analysis, but it is well known that water which has stood for some hours in a mixed-bed shows a relatively high conductivity. (Several 'bed-volumes' must first be run off to waste.) Clearly, this cannot be due to micromolecular electrolytes since these are effectively removed by the resins. It must be caused by colloidal polyelectrolytes, released by the resins and unable to penetrate into the resin particles of opposite charge because of size.

The purity of water from a mixed-bed column is therefore dependent on the time of contact with the resin. Rapid flow through a short column may allow electrolytes present in the feed water to 'break through', but slow flow through a long column may introduce organic polyelectrolytes.

Conductivities as low as 0·065 micromho cm.$^{-1}$ at 25° C. have been reported[1] for water from a mixed resin bed in favourable circumstances, and this is remarkably close to the theoretical value of 0·055 at 25° C. for perfectly pure water; but it is common experience to find values in the range 0·1–0·5 micromho cm.$^{-1}$. This conductivity value is a dangerous index. It can easily be dismissed as due to an 'insignificant trace' of electrolyte (for example, 10^{-6} *N* potassium chloride), but in fact may indicate a considerably higher (though quite unknown) amount of surface-active polyelectrolytes which may accumulate by adsorption on suitable surfaces.

With improvements in the stability of ion-exchange resins and careful attention to flow conditions, it may become possible to reduce the danger to almost negligible levels. But at the present time it is clearly advisable to avoid the use of resins entirely in all critical work in surface chemistry where small surface areas are concerned. Repetition of the experiments mentioned above, but using triple-distilled water finally condensed in silica, gave significantly different results for the suspended particles as well as for the glass surfaces.

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Void Nucleation Sites in Creep of Metals

FOR metals undergoing slow deformation at elevated temperatures, it has been shown that nucleation of voids by condensation of lattice vacancies requires either a very high concentration of excess vacancies (approximately 100 times the equilibrium value[1]), or very high concentration of stress[2]. It appears that such concentrations of vacancies are never approached even at high rates of deformation[3], so that voids must form at points where sufficiently large stresses develop. It has been suggested that ledges on a sliding grain boundary may provide these sites for nucleation.

The nature of ledges in the boundary is uncertain. Gifkins[4] suggested that they result from slip in one grain on planes almost perpendicular to the boundary being accommodated by slip in the adjoining grain. He believed that this mechanism required a pile-up of dislocations at the end of the slip plane. McLean[5] considered that the ledges are formed by glide of dislocations to the boundary. However, in these cases it might be expected that an increase in temperature or decrease in rate of strain (that is, increased duration of test) would facilitate such stress-relieving processes as movement of the ledge itself[5], or boundary migration, which would flatten out the ledges. Thus it appears that to form holes the ledges must be locked in position.

An alternative possibility is that the ledges causing formation of voids cannot be flattened out by migration due to their inherent structure. Thus suppose that a dislocation with a screw component normal to the plane of the boundary intersects the latter, then a step will be produced at the boundary similar to the steps observed in crystal growth. Such steps would inhibit sliding[5] and provide sites for the development of the high stress concentrations necessary for void nucleation. It may be possible for a number of nearby screw dislocations of the same sign to interact to form steps many atomic distances high. Dislocations of opposite sign emerging into the grain boundary near each other may combine to form terraces.

If the above mechanism of hole formation be correct, the ease of nucleation in a pure metal should be related to the size of the dislocation network, that is, to the number of sites available. In metals such as aluminium, which has non-extended dislocations, grain boundary steps might be annihilated by cross-slip of nearby dislocations to produce atomically flatter surfaces, as shown by Anderson and Dawson[6]. This would account for the absence of visible formation of voids in aluminium of very high purity fractured under creep conditions. In less pure metals or alloys, locking of the screw dislocations by impurities or by edge dislocations already anchored will be an important factor in causing formation of voids. The difficulty encountered in improving resistance to creep without adversely affecting ductility might also be due to the dislocations giving ledges at the boundary being anchored as a result of hardening within the grains.

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Fracture Markings in Polymethyl Methacrylate

THE surface markings on the fracture surfaces of glass and plastics show that the fracture is discontinuous and that patterns are formed through secondary initiations ahead of the main fracture front which unite to form the completed fracture surface[1-3]. Intersection of an isolated secondary fracture with the main crack front usually produces a parabolic marking[2,4]. Such centres of secondary initiation are microcracks, stress-raising discontinuities, or inclusions. New evidence has been obtained of the importance of such flaws in fracture behaviour and patterning in polymethyl methacrylate.

The tensile fractures of conventional test specimens of the material in cast and (dental) moulded form have been found to show striking differences. The fatigue fractures are likewise dissimilar. These differences are little affected by ambient conditions and have been ascribed to structural effects. The cast material, which was obtained commercially ('Perspex') and from syrup initiated by benzoyl peroxide, is macroscopically homogeneous, whereas the material moulded by dental techniques has a grain structure consisting of the original polymer particles, which are approximately spherical, embedded in a matrix of newly-formed polymer. This structure was clearly revealed by etching with 80–90 per cent nitric acid, which preferentially attacked the matrix material.

The tensile fracture (A.S.T.M. *D*638–52*T*) of the cast sheet ('Perspex'), both at 20–22° C. and 50–65 per cent relative humidity and at 37° C. and 100 per cent relative humidity, showed a typical cleavage appearance similar to that described by Kies[1] and George[2]. The smooth mirror-like surface had a number of parabolic markings (Fig. 1*a*). In contrast, the dental polymer showed a much more complex and discontinuous fracture (Fig. 1*b*). A small mirror-like origin was the centre of a number of rough concentric ridges made up of three-dimensional crack systems separated by smoother regions which themselves contained extreme complexity of markings. The fracture markings of cast sheet made from syrup (probably containing dust particles) were intermediate between these extremes, showing two or three ridges on a fairly smooth surface. Lowering the temperature and increasing the rate of loading caused the appearance of the fracture in cast sheet to approach that of the moulded material, but even at –60° C. the 'Perspex' fracture did not attain the complexity of the latter.

The long-term fatigue fractures (plane bending, 1–5 c./s., in room conditions, and at 37° C. and 100 per cent relative humidity) were different in morphology also. 'Perspex' showed a mirror-like origin and smooth surface, while the moulded polymer showed an area of origin containing propagation markings (Kies's "river systems") which gave place to a smoother surface on which the grain structure was delineated by many parabolic markings with heads concentrated at grain boundaries. The service

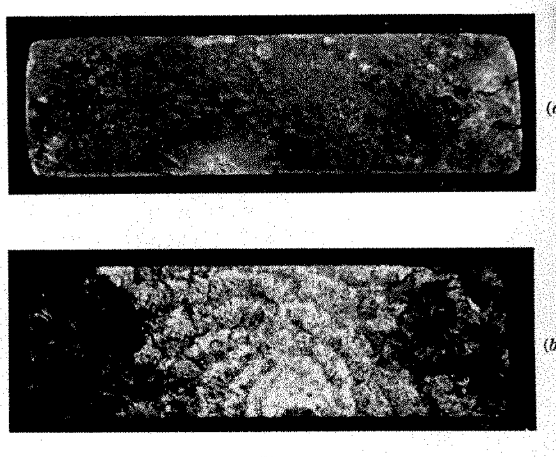

Fig. 1

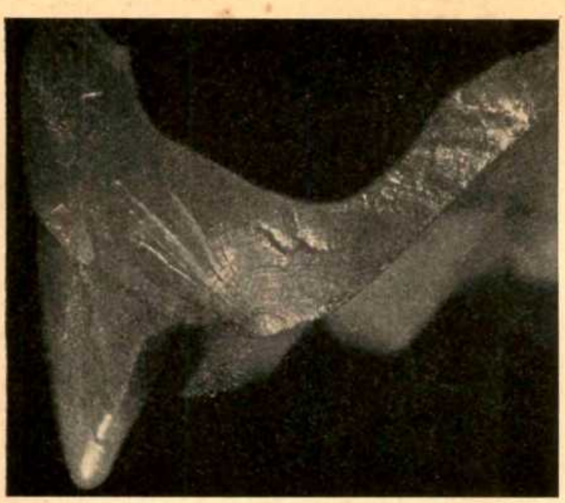

Fig. 2

fracture of polymethyl methacrylate upper dentures (Fig. 2) is similar, but shows the usual arrest markings.

The differences in tensile, and in fatigue, fracture can be explained in terms of the load magnitude, the flaw distribution, and their effect on crack propagation.

The tensile crack starts at some surface fault (occasionally internally) and rapidly increases in velocity as the stored elastic energy diminishes[2,5]. Where there are few major flaws as in 'Perspex', few secondary cracks are produced and these become enveloped quickly. Since the stress field contracts and crack velocity increases, however, the final fracture becomes complex[6]. In the moulded material the large number of major flaws results in the formation of multiple cracks at some critical velocity of the crack-front. The diminution in stored elastic energy results in a momentary hesitation while the energy builds up again, since more energy is required to start a crack than to propagate it[7]. Repetition of this cycle gives the regular discontinuous appearance.

In the case of fatigue failure, the initial cleavage fracture which occurs quite early in the test is propagated only slowly. Since the overload is small in the case of the moulded material, only the major flaws at grain boundaries act as nuclei.

This explanation is substantiated by the change in patterning which takes place if the cast polymethyl methacrylate is pigmented, when the tensile fracture becomes discontinuous as in Fig. 1*b*. A similar phenomenon has been observed in extruded polystyrene rod. Thus the mode of fracture in these materials is dependent on the number and distribution of flaws.

It is hoped that a fuller account of this work will be published elsewhere.

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April 21.

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Scintillation Counter for measuring Radioactivity of Vapours

The gas chromatographic technique of James and Martin[1,2] is often used to fractionate substances biosynthesized from precursors labelled with carbon-14. For the assay of carbon-14 in the various fractions it is necessary, at present, to collect the fractions individually and then transfer them to a counting device. Direct measurement of the radioactivity of vapours as they leave the chromatographic column would save much time and labour and improve accuracy.

We have devised an instrument which counts the carbon-14 content of vapours emerging from a gas chromatographic apparatus parallel with the analytical chromatographic record. In principle, the chromatographic vapours are condensed into a circulating liquid phosphor: a solution of diphenyl oxazole in xylene. The scintillations excited in the phosphor by the carbon-14 are detected with a photomultiplier.

Fig. 1 illustrates the instrument diagrammatically. The vapours and carrier gas (nitrogen) flow through capillary tube *A*, which is heated electrically to the temperature of the column; then they bubble into the liquid phosphor, which is kept in vigorous circulation around the circuit *BCDE* by the bubbles of carrier gas rising in tube *B–C*. As the vapours are soluble in xylene and have high boiling points they are stripped from the carrier gas on entering the liquid phosphor. Jacket *F* cools the xylene on its path from *A* to the counting cell *S*. This cell is a cylindrical cavity (1 cm. deep, 15 ml. capacity) formed by pressing a polyethylene cup over the window-end of a photomultiplier. Thus the scintillations produced in the phosphor are 'seen' directly by the photomultiplier, there being no loss of light due to interfaces between the phosphor and the photomultiplier.

The phosphor is introduced and removed through a thin polyethylene tube, inserted into opening *X*, and extending to point *E*. The opening *X* also allows the carrier gas to escape. A combined support and lead shield holds the photomultiplier horizontally, the whole assembly being placed in a lagged and light-tight box. Cooling liquid at about 0° C. is pumped through tubes in the side of the box and circulated through the jacket *F* and the photomultiplier support.

Pulses from the photomultiplier are amplified and fed into a rate-meter and recorder. The record of

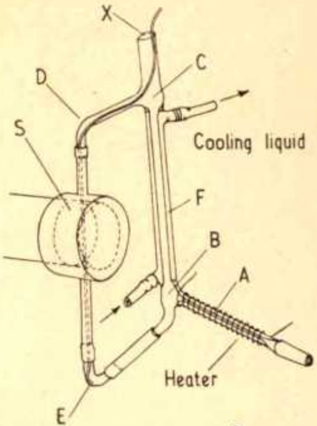

Fig. 1. Instrument for measuring radioactivity of vapours

radioactive counts is of integral form, identical in shape with the records of chromatograms obtained from the automatic titration instrument of James and Martin[1].

By injecting a known amount of fatty acid labelled with carbon-14 into the phosphor, the overall efficiency of counting was found to be approximately 30 per cent, which is satisfactory as the photomultiplier 'sees' only about two-thirds of the total volume of phosphor. The background count, including electronic noise, was 3·8 counts/sec.

A full description of the technique and constructional details of an improved apparatus will be published elsewhere.

We wish to thank Dr. G. Popják for suggesting the technique and for his advice and encouragement, and Messrs. E. K. Cole for the loan of the photomultiplier.

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May 14.

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Counting Error due to Overlapping Particles in Thermal Precipitator Samples

THE thermal precipitator[1] is widely used as a standard instrument for sampling dust clouds. The dust from a measured volume of air is deposited on glass slides and is afterwards counted under a microscope.

Some particles consist of several smaller ones clumped together and these 'aggregates' are counted as single particles. Other particles are deposited so that they overlap ones already deposited, producing spurious aggregates. These cannot be distinguished from true aggregates and consequently the dust concentration is under-estimated. In the many previous tests of the thermal precipitator the magnitude of this error does not seem to have been investigated.

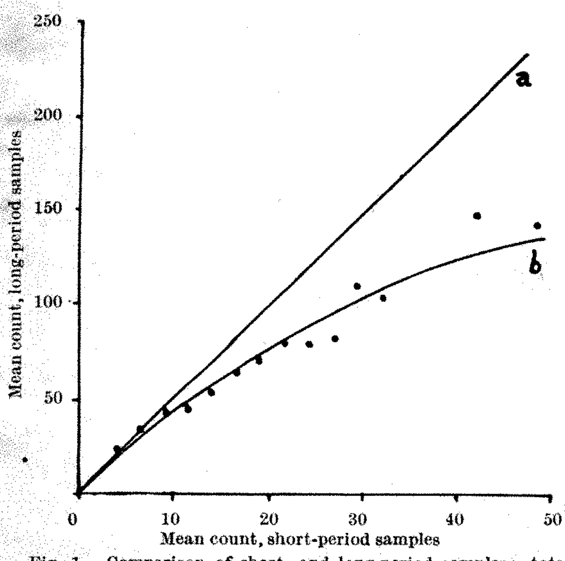

Fig. 1. Comparison of short- and long-period samples; total number of particles per 20μ traverse; *a*, no overlapping; *b*, fitted curve

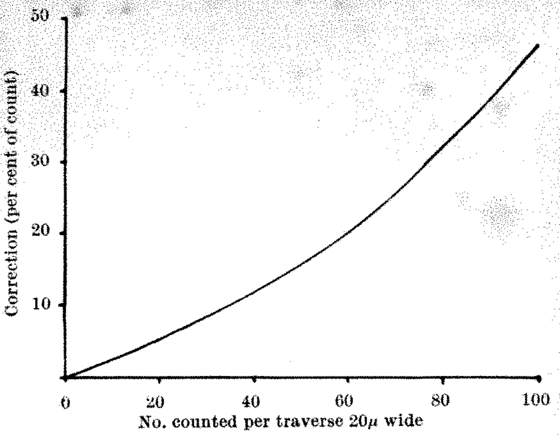

Fig. 2. Correction to be added to the count

Two thermal precipitators were placed in a colliery and pairs of samples were taken in which one of the instruments samples for five times as long as the other. A comparison of corresponding mean counts from the two instruments is given in Fig. 1. The short-period counts were grouped and the corresponding long-period means calculated. In the absence of overlapping the long-period counts would be five times the short-period counts, shown by the straight line. In fact they were less, by an amount which increased with the density of the deposit, indicating that a considerable amount of overlapping occurred in the denser samples.

The mean projected area of the particles was $18{\cdot}6\mu^2$. With finer dusts the effect of overlapping will be smaller.

A curve was fitted to the results using an equation similar to those derived theoretically by other workers[2]. From this curve we can estimate the correction to be added to the number counted to make it equal to the number deposited (Fig. 2).

The results show that with sample densities of 25–50 particles per 20-μ traverse, the true dust concentrations of the coal dust cloud are between 5 and 15 per cent higher than those estimated from the counts. Other workers have recommended densities several times greater than this[1,3]. If such densities were in fact used, the overlap error would be very large. The error can be reduced by using very low densities, but the extraneous contamination then becomes an increasingly large error. Consequently it does not seem to be possible in practice to avoid the error introduced by overlapping particles when sampling airborne dust similar to that occurring in this coal mine. The value of the thermal precipitator as a standard reference instrument in coal mines is therefore open to doubt and needs re-investigation against an absolute standard such as a sedimentation cell.

A full report of this work will be published elsewhere.

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Pneumoconiosis Research Unit (Cardiff),
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FORTHCOMING EVENTS

Wednesday, July 16

International Palæontological Union (in Room 128, Royal School of Mines, Prince Consort Road, London, S.W.7), at 4 p.m.—General Meeting. (Second General Meeting on July 17.)

Friday, July 18

Biochemical Society (in the Department of Biochemistry, The University, Sheffield), at 2 p.m.—375th Meeting.

Saturday, July 19

British Psychological Society (at Birkbeck College, Malet Street, London, W.C.1), at 2.30 p.m.—Prof. E. N. Sokolow (University of Moscow): "Objective Study of Hearing Disorder".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Lecturer (with a first- or second-class honours degree and experience in lecturing in soil science and agricultural chemistry) in Soil Science and Agricultural Chemistry at Shambat Agricultural Institute, Education Division, Ministry of Agriculture, Sudan—The Sudan Embassy, Personnel Section, Cleveland Row, London, S.W.1, quoting Ref. "Lecturer Soil Science 4/447" (July 15).

Senior Lecturer or Lecturer (male, British, with a first- or second-class honours degree in mechanical engineering) in the Applied Mechanics Department; and a Senior Lecturer or Lecturer (male, British, with an honours degree or equivalent in electrical engineering, and preferably special experience in telecommunications) in the Physics and Electrical Engineering Department—The Director of Studies, R.N. College, Greenwich, London, S.E.10 (July 18).

Area Chief Scientist (with a good degree (or equivalent) in chemistry, physics or fuel technology and wide industrial experience) in the Cannock Chase Area—The Divisional Chief Staff Officer, West Midlands Divisional Coal Board, Himley Hall, Dudley, Worcs, quoting NA (July 19).

Assistant, Grade B (preferably with experience in industry, teaching and/or research), in Inorganic Chemistry—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (July 19).

Assistant Lecturer, Grade B (with professional qualifications in biology and preferably the ability to teach microbiology or bacteriology) in Biology at the City College of Technology, Byrom Street, Liverpool—The Director of Education, City of Liverpool Education Committee, 14 Sir Thomas Street, Liverpool 1 (July 19).

Assistant Lecturer in the Department of Numerical Automation, with special reference to electronic calculation and numerical analysis—The Secretary, Birkbeck College (University of London), Malet Street, London, W.C.1 (July 19).

Assistant Engineers (with the H.N.C. or a degree, or other suitable technical qualifications in physics, applied physics and mathematics, or electronics, and preferably some practical experience) in the Design Section of the Nuclear Power Plant Design Branch at Headquarters, London, to work on problems of radiation levels in relation to health physics—The Chief Personnel Officer, Central Electricity Generating Board, 24–30 Holborn, London, E.C.1, marking envelope "Confidential" and quoting Ref. N/173 (July 21).

Assistant Lecturer in the Department of Chemistry and Biochemistry—The Dean, St. Thomas's Hospital Medical School, London, S.E.1 (July 25).

Lecturer (preferably with qualifications in mathematical statistics) in Statistics—The Secretary, The University, Aberdeen (July 25).

Lecturer (with postgraduate research experience and preferably previous academic teaching experience) with special interests in Physical-Organic Chemistry—The Clerk to the Governors, Chelsea College of Science and Technology, Manresa Road, London, S.W.3 (July 26).

Regius Chair of Botany in the University of Edinburgh—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (July 28).

Research Assistants (with, or expect shortly to possess, an honours degree in chemistry, or A.R.I.C.) in Organic and Organometallic Chemistry—The Registrar (Room 22, O.R.B.), The University, Reading (July 31).

Assistant Professor of Metallurgy—Head of the Department of Mining and Metallurgy, University of Alberta, Edmonton, Alberta, Canada (August 1).

Lecturer in Pharmacology—The Registrar, Trinity College, Dublin (August 1).

Lecturer in Education at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

Lecturer (qualified in either mycology and plant pathology, or physiological or biometrical genetics) in Botany; a Lecturer or Senior Lecturer in Fluid Dynamics; and a Lecturer (preferably strong in applied mathematics or physics and interested in fundamental geophysics rather than geophysical prospecting) in Geophysics at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 4).

Professor of Botany, a Professor of Chemistry, a Professor of Geology, a Professor of Physics, and a Professor of Zoology—The Registrar, Canberra University College, Canberra City, Australia (August 8).

Senior Lecturer in Histology, and a Lecturer in Anatomy, at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 11).

Physical Metallurgist or Metal Physicist (Principal Scientific Officer) (with a first- or second-class honours degree in metallurgy or comparable qualification, and at least three years relevant postgraduate experience) with the Admiralty at Rosyth—Civil Service Commission, 30 Old Burlington Street, London, W.1, quoting S.4858/58 (August 12).

Chair of Geography in the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 13).

Lecturer or Senior Lecturer in Mathematics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

Assistant Biochemist (young graduate with a good honours degree in chemistry or equivalent qualification, and preferably with analytical experience) in the Department of Pathology, for duties which include participation in research, particularly in the field of steroids—The Group Secretary, Queen Elizabeth Hospital for Children, Hackney Road, London, E.2.

Biochemist (medical qualification not essential), to conduct research in the field of rheumatic diseases—The Director, Rheumatic Unit, Northern General Hospital, Ferry Road, Edinburgh 5.

Joseph Lucas Fellow, for research in the field of Electrometallurgy, with emphasis on the growth, structure and mechanical properties of electrodeposits—The Registrar, The University, Edgbaston, Birmingham 15.

Metallurgist, Chemist or Physicist (graduate, preferably with language knowledge) in the Information Department, for work on all aspects of recording and transmission of information on extraction, fabrication and use of non-ferrous metals—The Secretary, British Non-Ferrous Metals Research Association, Euston Street, London, N.W.1.

Scientific Officer (with a good science degree, a reading knowledge of two European languages (preferably other than French or German), the ability to write good English and preferably a knowledge of soil science and plant physiology), for work in a scientific information service involving abstracting and indexing—The Director, Rothamsted Experimental Station (Commonwealth Bureau of Soils), Harpenden, Herts.

Technician (with H.N.C. or equivalent in chemistry and/or physics, and preferably skill in laboratory techniques, for example, glass-blowing or electronics), to carry out experimental work and assist in the construction and maintenance of apparatus in the Department of Chemical Microbiology—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/5.

REPORTS and other PUBLICATIONS

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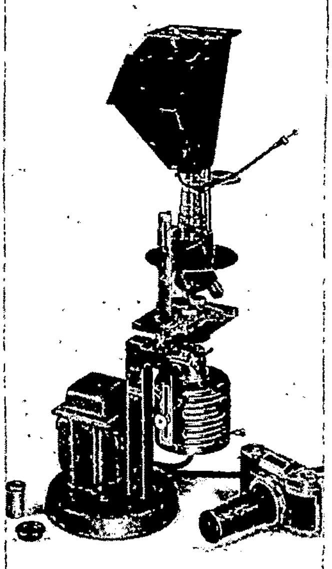

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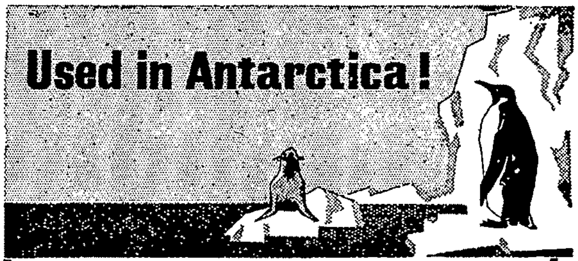
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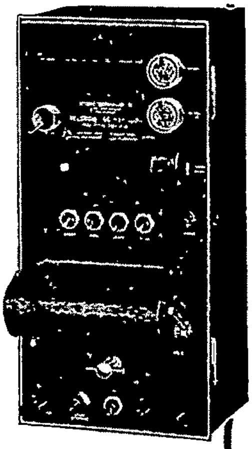

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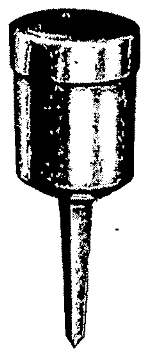

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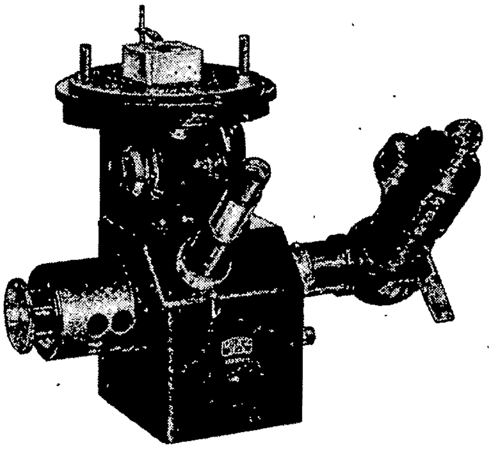

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EXPANSION OF UNIVERSITY EDUCATION IN BRITAIN

THE report on "A Policy of University Expansion", which was adopted by the Council of the Association of University Teachers on December 18, 1957, was only published* in May after the Government had announced a further grant for university building in Britain of £15 million in each of the years 1960–63, and set a target of 124,000 students, with a temporary increase of 10 per cent during the period 1965–70, in place of the 106,000 students previously suggested by the Treasury. In the meantime, however, while the importance of quality in education has received repeated emphasis in various pronouncements on industry and education, and particularly in A. G. Korol's study of Soviet education for science and technology, a series of articles in *Research* on the educational framework of an industrial society have explored further the implications for the universities of the demands of technology. Much attention has also been directed to the question of university awards, and on June 6 the Minister of Education, Mr. Geoffrey Lloyd, announced a new scale of grants for students which, with other changes, will cost nearly £2,000,000 in a full year.

Under the new scales, the parental contribution is decreased while the grants themselves are increased; and the Minister has also approved increases for students at training colleges for technical teachers which implement recommendations of the Willis Jackson Committee on the supply and training of teachers for technical colleges, besides recommending to local education authorities that students more than eighteen years old pursuing degree or equivalent courses at technical colleges and similar institutions in Britain should receive awards at the university rate. He has also again emphasized the importance he attaches to the maintenance of uniformity in grants to university students throughout the country, and hopes that all local education authorities will adopt the new rates for holders of awards in their own areas. While the increases are roughly double those made three years ago, they increase the disparity between grants for those in training colleges and those for holders of university awards, and, from this point of view, may do nothing to ease the critical shortage of teachers. It could be argued that it would be administratively much tidier to abolish the means test altogether and also the tax allowances for children at a university; but nevertheless the new scale of parental contribution represents an honest effort to eliminate, within the limits set by the Education Act, what may be described as the 'second surtax' hitherto levied on the higher paid parents of intelligent children. It will not enable every gifted pupil to accept a university place without imposing real sacrifices on his family, but it should reduce further the risk that purely financial reasons will cause some really gifted individual to forgo the training which would develop his talents to the full. Even if it did no more than ensure for the nation the services of half a dozen such outstanding scientists or technologists, the new scale would be worth while; for what needs to be remembered above all in considering the expansion of university and technological education is the importance, not of seeing that every potential student of marginal ability has a university place, but of ensuring that no boy or girl of really outstanding ability misses one.

We seem, in fact, to be in some danger of expanding university and technological education too much in the former direction. There are limits, as the Chancellor of the Exchequer quite rightly said in the House of Commons, to what Britain can spend even on university education, and it is at least debatable whether the type of university education which the really gifted should receive is exactly that which is best suited to the average university student. We may be attempting to provide many students with a much more expensive type of education than they need and one from which they are unlikely to profit fully.

This may be represented as an attempt to lower university standards, but it indicates the type of question about the nature and purpose of a university education which should be asked in considering the report of the Association of University Teachers and such statements as that of the Labour Party on "Learning to Live". They are no less relevant in discussing particular aspects of university education, such as the founding of Churchill College at Cambridge and the recent statement on university awards, and appear largely to have been ignored by the National Union of Students in its comments on the new scale, though many of the changes are welcomed.

The Association of University Teachers begins with a general discussion of the nature of university education, in which the unique nature of the universities as institutions for both the advancement and the dissemination of knowledge is rightly stressed. The special value of a university education is based mainly on the way in which it brings the student in personal contact with those who are advancing knowledge; on its unhurried character, in which acquisition of the art of learning takes precedence over acquisition of factual knowledge; and on the varied types of student and scholar and the branches of learning with which the student is brought into contact. All these features of a good university education could be destroyed if student numbers so increased in relation to the number of teachers as to make research difficult and personal knowledge of individual students impossible, or by attempts to produce excessive numbers of fully trained specialists.

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* Association of University Teachers. Report on a Policy for University Expansion. Pp. 14. (London: Association of University Teachers, 1958.) 3s.

This is rightly represented by the Association, irrespective of whether its views as to the practicability of sufficiently increasing the number of university teachers or on the conditions necessary to recruit and retain them are sound. What needs to be emphasized is that it should not be assumed that the student himself is necessarily to advance knowledge. Excessive emphasis on research may increase the cost of a university education, fail to develop many students according to their innate abilities and provide too many graduates of a type and outlook which industry finds unsuitable.

In this connexion, observations on residence and on the size of a university are pertinent, and the paper which Sir Keith Murray read to the Royal Statistical Society on May 14 is of special interest. The Association, stressing the importance of a sufficient leavening of senior members of a university, endorses the view that a university hall of residence should have some 150 students, and it is convinced that new halls of residence are essential to any scheme for a substantial increase in the number of students. Sir Keith Murray is concerned not simply with the possibility that the universities of Britain may become too large to serve the national purpose, but with the effect of the current tendency on the work of the universities themselves—whether we might do better to spend the same amount of money on fewer people, as Lord Woolton recently speculated at Founders' Day in Manchester.

During 1955–56, Sir Keith observed, excluding Oxford, Cambridge and London, sixteen university institutions, containing 35·2 per cent of the students, had less than 2,000 students. By the late 1960's, only four institutions, containing 9·2 per cent of the students, are expected to contain less than 2,000 students, and more than half the university students will be in institutions of more than 5,000. The Government's university building programme already mentioned visualizes an increase of 50,000 students on 1955 by the mid-1960's, and Sir Keith is seriously concerned as to the possibility in such conditions of maintaining the three ancillary freedoms on which the maintenance of freedom of thought depends. That freedom does not require simply freedom from any form of political intervention; it may also be prejudiced by failure to maintain the freedom of a university to make its own appointments to teaching posts, and freedom from external control over either what is taught or admissions.

The universities therefore should not be content to consider expansion mainly in terms of the availability of students of appropriate intelligence quotient. On that basis the Association of University Teachers estimates that the schools could increase the number of pupils taking two subjects in the General Certificate of Education at advanced level by 55 per cent on the figures for 1954, and that the university intake could increase correspondingly. It also estimates that the proportion of the population with high enough intelligence quotient to meet present university entrance requirements is 6·9 per cent compared with the 3·2 per cent who reached the universities in 1954. Even 95 per cent of these would require 145,000 university places by 1965—some 10,000 more than the maximum provided for in the Government's revised plans announced last February.

This, however, is the target which the Association of University Teachers accepts. It suggests that the university population should increase by 35 per cent on 1956–57 by the academic year 1962–63, and by 63 per cent from 1966–67 onwards. Non-collegiate universities should not be encouraged to expand beyond 4,500 students—in other words, to more than double their size—in ten years. This policy would provide a maximum of 23,000 fewer places than the target figure, and the Association suggests accordingly the founding of new universities so that they can make a significant contribution during the period 1961–66. These universities, which should be largely residential, should give their own degrees, initially under the sponsorship of some existing universities. Sites mentioned in the report are Norwich, York and Leamington and, because of the location of many research associations there, Leatherhead. In technology, the Association recommends the use of postgraduate courses to train academically qualified graduates for specialized professional employment.

Even if the assumption that university places should necessarily be available for all school leavers of high enough intelligence quotient to meet existing university entrance requirements is unchallenged—and this ignores the claims of both the colleges of technology and the technical colleges and presupposes that a university education is the most desirable means of training men and women for leadership and responsibility in any sphere of life—targets of that magnitude are best justified on practical rather than theoretical grounds. Sir Solly Zuckerman has recently examined, in the *Universities Quarterly* of May, the implications of the policy of technical education in Britain outlined in the White Paper of 1956, and of the latest proposals for university expansion to provide the estimated necessary output of professional scientists and engineers which would be needed by 1970. During the next ten to fifteen years that report suggested we should aim at an annual output of about 20,000 professional engineers and scientists compared with 10,000 at the time of the inquiry.

If the technical colleges succeed in implementing the White Paper policy, Sir Solly Zuckerman estimates that by 1965 they could supply about 9,500 professional scientists and engineers, including 1,000 with external university degrees. This would rise to about 10,500 by 1970. By the end of the 1960's the university output should rise to 11,000, including 1,500 qualified in special technologies, or 4,500 a year more than in 1955–56. The increase in university places provided in the February 1958 statement should be sufficient to enable the universities to play their part in doubling the present output of scientists and engineers in Britain, and with 20,000 places for students of medicine, dentistry, agriculture and veterinary science would still leave 50,000 places for the humanities compared with 37,000 in 1955–56.

Sir Solly points out, however, that all this depends on the ability of the schools to supply the entrants. The technical colleges, for example, will require an input of 23,000 by 1967–68, and for the current academic year entries in science and technology are 10,800 compared with 7,300 in 1953. A university population of 124,000 implies an annual entry of 35,000, of whom 2,500 would be from overseas, and the 10 per cent increase would raise this to 38,000 in the late 'sixties. Allowing about half the technical college entry to be from school sixth forms, with some 10,500 for teachers' training colleges, it will be seen that in 1967–68 some 53,000–56,000 from the schools will be required for academic education out of an intake of 64,000–67,000, compared with 37,000 in 1955–56.

Figures like these put the question of teachers in its right perspective, and especially the critical importance of science teachers. If the plans already laid are, in fact, to meet the nation's requirements, their implementation must proceed smoothly and unhindered either by critical shortages or by delays. The Association of University Teachers regards the availability of staff as the most probable limiting factor in the expansion of university education in Britain, and is dubious as to the ability of the universities to recruit a sufficient proportion of first-class honours graduates. It may well be necessary to increase the present proportion of 41 per cent of second-class honours men on university staffs; but the position is one that calls for even greater attention to the efficient use of university staff. The provision of auxiliary staff, known to be comparatively low in universities compared with elsewhere, may be a most important factor in maintaining university standards with a smaller number of highly qualified staff. It is, however, no less important that the needs of further or higher education for those not up to the level of two passes at advanced level of the General Certificate of Education should not be overlooked. As the report on "Early Leaving" indicated, there is here a most important source of the technicians and auxiliary staff on which the most efficient use of the more highly trained scientist, technologist or administrator depends.

The Association of University Teachers cannot fairly be charged with timidity in its approach to university expansion, though it could well be regarded as questioning the soundness of the ultimate target of at least 160,000 places advocated in the Labour Party's statement, "Learning to Live". Nevertheless, in its reference to the universities and to technical and scientific education that statement is reasonable, though the pertinent questions raised about the universities, such as their size, distribution and finance, should, it is suggested, be referred to a royal commission. That suggestion, however, is not without value, and though it seems to lack the urgency needed it could provide some of the safeguards which would encourage constructive response by the universities themselves. There is genuine concern in university circles that a university may cease to be a university if expansion proceeds without due regard to the importance of adequate library facilities, the ratio of staff to students and the balance between different faculties.

No one who studies the annual returns published by the University Grants Committee would suggest that fears on such points are unreasonable. The Association of University Teachers could well have put the case for library expansion much more strongly, for the returns indicate little proportionate attention to the expansion of university library facilities in the post-war years. This, however, is only one illustration of the need for a marked improvement in the real resources of universities, to enable them to make experiments in the curriculum and the varieties of degrees offered, and it is not too much to urge that the higher the proportion of the population entering the universities, the more essential it is that experiments should be made and variety offered.

Prof. Asa Briggs has argued very reasonably in the *National and English Review* for greater differentiation between the universities. The provincial universities should not seek to imitate Oxford and Cambridge, but emphasize and develop their own distinctive advantages. Diversity already exists between the provincial universities, but more is possible, and the greater academic mobility which, as Prof. Briggs points out, is also needed, could assist.

What are needed here—and indeed at all stages in concerting a policy of university or technological or technical education—are vision and judgment, in order to avoid dissipation of resources on secondary objectives and the loss of the full effect of sound measures for lack of essential support at some stage or other. There is substance in the argument, for example, that even the creation of a new college, such as Churchill College, except as part of a considered university policy, could prejudice decisions on vital national questions such as the proper size of Oxford and Cambridge, the location and character of a third residential university, and whether a major new college of technology should be located near some great centre of industry. Without vision, too, doctrinaire considerations may affect adversely critical factors like academic autonomy and the co-operation which is essential from many varied interests and sectors in the national life.

The report of the Association of University Teachers touches on several of these important issues, but by no means all. Sir Solly Zuckerman indicates more clearly how university expansion depends critically upon educational policy in the schools, but even this pragmatic approach by itself is not enough. The continuing need is for independent, uninhibited and constructive thinking about the nature and purpose of university education and their relevance alike to the needs, aspirations and capacities of both students and teachers, and to the needs of the society in which universities exist. Another major consideration is the magnitude of the resources which society can place—and is willing to place—at the disposal of universities, colleges of technology, technical colleges and the schools.

GEOGRAPHICAL DISTRIBUTION OF ANIMALS

Zoogeography

The Geographical Distribution of Animals. By Dr. Philip J. Darlington, Jr. Pp. xi+675. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 120*s*. net.

The Faunal Connections between Europe and North America

By Carl H. Lindroth. Pp. 344. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd.; Stockholm: Almqvist and Wiksell, 1957.) 120*s*. net.

THESE two books are both written by experienced taxonomists with special knowledge of the Carabid beetles but much wider interests as well, and both are stamped with the care and integrity of good museum research, backed with a great deal of collecting in various places. Since the publication of A. R. Wallace's classical book on "The Geographical Distribution of Animals" in 1876, there has been no general handbook of zoogeography giving reliable detailed facts about distributions for the whole world, and a balanced, critical assessment of their origins. There have been plenty of interesting essays as well as a lot of very unreliable speculative books and papers, many good regional surveys, studies of island groups or of ancient lakes—a mounting pile of unrelated facts and theories; but nothing one could use for a general interpretation of present distributions and faunal history.

Dr. P. J. Darlington's book goes a very long way towards providing an authentic review of our knowledge of the distribution of vertebrates (to which his analysis is confined), and some way toward fitting them into faunal history. But most of his text is a solid concrete-mix of facts and very closely woven comments upon them, only seventy pages being devoted to a general statement of his views on faunal history as a whole. About a quarter of the book is actually composed of tables summarizing the present and fossil distribution of each family of vertebrates, that is, of the freshwater and terrestrial ones. These are the result of twenty years very careful compilation and checking, and are presented in a thoughtful and critical manner, though in such complex detail that reading is not easy. But any zoologist who enjoys browsing in dictionaries can only emerge from reading this material with an enriched realization of the complexity and interest of zoogeography.

The text has a number of maps, though no list of them is included. The world maps are on an orthographic projection, so that two overlapping maps are needed for a whole world distribution. The author objects to Mercator's projection as misleading; but even though it is a scale convention, I think it much more convenient to look at the world in one piece. The ability of animals to spread quite quickly in the absence of barriers is stressed by the author himself, and this seems to make differences of relative map scale fairly unimportant. He uses wide gridiron markings to show distribution areas, presumably to avoid a misleading appearance of precision in mapping ranges. These make the world look as if it has suffered injuries and been covered with sticking plaster—a convention already suitable to conservation, and perhaps soon also to natural zoogeography.

Dr. Darlington has a highly personal style, his text is laced with decisive opinions, but most of his conclusions seem sound, though perhaps rather conventional. One feels that if a new and daring idea were to be put forward (for example, by another Wegener) he might quickly reply: "But do you realize that didelphids died out temporarily in North America in the Upper Miocene", or some such hard fact—and that in many instances he would probably be right. But many of his opinions cannot be proved, for that is the curse of so much in zoogeography, where the final answers to many of the largest questions must await the further discovery of relevant fossils. One general criticism can be made of the book (which is so genuinely learned and anxious to state conclusions fairly), apart from its lack of ecological ideas. We know that of the great groups of animals like freshwater fish, birds and mammals, that underwent rapid evolution during the Tertiary isolation of continents, good fossil history is available only for some mammals. Most terrestrial and freshwater groups had already evolved far towards a final stage before these continental isolations arose. What we see now is a complicated mosaic of earlier wide distributions now contracted or broken in bits; regional ones attributable to Wallace's 'realms'; redistributions from about the Pliocene onwards; and later blurrings caused by man. For the explanation of most of these patterns we depend on complicated cross-arguments (this book abounds in cross-references) unsupported by a fossil record. This is why a work that concentrates on describing the modern distributions of vertebrates can only include a small amount of proved faunal history to go with it. But zoologists will for many years seek some of their basic facts here, and find them discussed in honest and sensible terms. They will also encounter some ideas that may be new to them, such as the ancient Central American sub-continent that is postulated, and the notion that Madagascar, like New Zealand, may never have been joined to any mainland mass.

Dr. C. H. Lindroth has written a special monograph rather than a book for general reading. It is in three almost equal parts. The first is a detailed tabulation of the present distribution of about 900 species of animals common to Europe and North America, though many of them range much wider, especially into Asia. They include mammals, birds and fish, and a selection of insects, spiders, myriapods, land isopods, molluscs and worms. The list is not claimed to be anywhere near complete, because the author has sensibly chosen groups of species the taxonomy and distribution of which are likely to be reliably known. About 45 per cent of these species include introductions by man. The second part of the book is an analysis of introduced forms, especially those taken accidentally in the ballast of shipping, with some personal surveys of ballast ground-faunas both in Britain and Newfoundland, and a historical survey of earlier shipping trends. It is concluded that introductions by this and other means have been about ten times more common from Europe to North America than in the other direction. The third is the least satisfactory part of an interesting and original monograph, as it discusses in a manner which is rather too condensed a great many controversial questions of faunal history before the influence of man began. Nevertheless, the author has brought out the rather small common element in the native faunas (at any rate at the species-level) on opposite sides of the Atlantic, and the growing force of invasions made possible by shipping in modern times. There are some good maps, but the book could have been more cheaply printed without loss of usefulness and with more likelihood of being read by students.

CHARLES S. ELTON

EUROPEAN ORTHOPTERA

Die Geradflügler Mitteleuropas

Von Kurt Harz. Pp. xxiii + 494 + 20 plates. (Jena: Gustav Fischer Verlag, 1957.) 69.20 D.M.

THERE has been no book on the Central European Orthoptera since 1901, when the first edition of Tümpel's brief, and now quite out of date, "Die Geradflügler Mitteleuropas", was published. Indeed, with the exception of France, no single country in Europe has its grasshopper fauna covered at all comprehensively, even at the present time. Kurt Harz's book has thus been presented to an entomological public which conspicuously lacks an authoritative work on the Orthoptera of Central Europe. It is true that our knowledge of such aspects as the biology and distribution of European grasshoppers is still little better than rudimentary, but this must be due in no small way to the absence of a publication presenting an up-to-date picture of what facts have so far been established.

The area covered by this book extends east to west from the Rhine valley to the Carpathians, and north to south from the north coast of Germany to the Alps. More strictly, the author regards the following countries as being in Central Europe: Germany, Switzerland, Liechtenstein, Austria, Poland, Czechoslovakia, Hungary, and Roumania. The author, however, recognizes that the Central European fauna has little respect for political boundaries, and he does not therefore exclude Belgium, Holland, Luxembourg, and a strip of northern France. In his introduction, he makes the interesting point that, of the 200 species of his group which occur in the area thus delimited, only 45 occur in Hungary or Roumania or south of the Alps.

Included under the heading "Geradflügler" are the Orthoptera in the widest sense, and the Dermaptera. Following the modern trend, the Blattodea, Mantodea, and Saltatoria are treated as separate orders. Also conforming to recent practice, though less justifiably, many of the groups generally regarded as subfamilies have been given family status.

The arrangement of the book is very systematic and makes for great ease of reference. Even very minor subdivisions of the subject-matter, some occupying no more than two or three lines of print, are given separate sub-headings, and all these, very commendably, are listed in the contents—which occupies a dozen pages. Under each order there is first a general account of the morphology, anatomy, physiology, embryology, and behaviour of the insects included; notes on capture and preservation are also given. Although the information on many of these topics is very brief, the wide coverage of the subject-matter is commendable and greatly increases the value of the book.

Identification keys are given at every level of the classification. A certain amount of ease in identification must therefore have been sacrificed in order to show the natural relationships of the members of each group. For example, the user is obliged to make a critical examination of the subfamily characters (frequently microscopical and often difficult to appreciate) in order to identify a species which may have obvious spot characters.

Under each species the author gives a brief description and notes on the biology of the insect. For the Saltatoria quite comprehensive accounts are also given of the various types of stridulation of each species. The treatment of each insect concludes with a fairly detailed account of its distribution.

The book is profusely illustrated: there are 255 text-figures (including a number of photographs) and 20 colour-plates. Many of the text-figures are redrawn from previously published works but a large proportion is original. These, the photographs, and the colour-plates, are all apparently the work of the author. The standard of the drawings in the text is poor; the intention, evidently, was not to present a high degree of accuracy or to give the illustrations artistic finesse. Difficult points which arise in the identification keys are, however, adequately figured, and a drawing of the whole insect is given for almost every species. The colour-plates are again not of the highest quality, but nevertheless form a most useful supplement to the text-figures. Pictures of some of the different colour-varieties of a few species of Acrididae are wisely included among these plates.

The book concludes with a short glossary of technical terms, a list of abbreviations of authors' names, a comprehensive bibliography including some 500 titles, and indexes to both German vernacular names and Latin names of taxonomic categories.

It should be emphasized that this book is not written for the casual nature lover and is too advanced for even the most ardent schoolboy enthusiast. It is rather aimed at serious naturalists and specialists in entomology, and is sufficiently authoritative and comprehensive to be quite indispensable to any keen student of European Orthoptera. The author has clearly devoted many years to the study of his subject and the literature relating to it; his object in writing the book—to present an up-to-date basis for further studies and to show where the biggest gaps in our knowledge lie—will surely be realized.

DAVID R. RAGGE

MICRO-ORGANISMS IN MILK AND MILK PRODUCTS

Dairy Microbiology

By Prof. Edwin M. Foster, Prof. F. Eugene Nelson, Prof. Marvin L. Speck, Prof. Raymond N. Doetsch, and Prof. Joseph C. Olson, Jr. Pp. xvi + 492. (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1957.) 5.65 dollars.

THERE are few books on dairy microbiology and their usual pattern is a description of microbial defects in milk or milk products, the naming of the causal organisms and suggested measures for control. The authors of "Dairy Microbiology" attempt first to provide for the reader a foundation of basic information on microbes of importance in the dairy industry, which will enable him not only to have a little insight to taxonomy, but also to appreciate why specific defects may occur. Before these defects are considered the reader is given a short course (or refresher, as the case may be) on the control of the growth of micro-organisms, their destruction by physical and chemical agents, and the various methods used to examine dairy products for micro-organisms. In the introduction the concept of the speed with which micro-organisms can bring about changes in milk is vividly presented by a discussion of the ratio of cell volume to surface area. A quart of milk soured by *Streptococcus lactis* contains about 10^{12} cells which would present an enzymatically active surface of about 50 square feet.

A small weakness of the book is the rigid insistence on the logarithmic order of death. While such a conception is convenient for the purpose of calculation, this aspect could have been maintained by the statement that for most purposes the speed of reaction was so great that the sigmoid nature of time-death curves could not be determined, and that they appeared to be logarithmic. This would prevent the discriminating reader from puzzling over the reason why one class of biological life should differ from all the rest in that the cells were all of uniform resistance.

It is, of course, relatively easy to make criticisms of any text-book dealing with a wide subject. The applied aspects cover the microbiology of milk on the producing farm, of market milk and related products, of condensed, concentrated and evaporated milk, of ice cream, fermented milks, cheese, cream, butter and waste products.

This book suffers from the defect we have come to regard as usual in American work: insufficient reference is made to European work.

The book is well indexed and illustrated. A 'modern touch' is given to the book by the fact that the illustrations are frequently carried over the margin to the edge of the page. In some cases this allows a saving of space and the reproduction of a larger picture.

While this book is written mainly from the American point of view, a great deal of what it contains is of use to dairy technologists in other continents.

L. F. L. Clegg

ROYAL JELLY

La Gelée Royale des Abeilles

Son Histoire et ses Propriétés, sa Composition—ses Utilisations en Diététique et Thérapeutique Humaines. Par B. de Belvefer. Pp. 470. (Paris: Librairie Maloine; London: Apiserum (James Lowe), 1958.) 4,000 francs; 84*s*.

This volume starts with a famous quotation by Pasteur, pointing to the distinction between science and its applications. Unfortunately the material in the book is so arranged that it presents the development of our considerable and diverse knowledge concerning bees just as a prelude to the benefits which, in the author's view, humanity will reap from the uses of royal jelly in various medical fields, such as geriatrics and dermatology. This appears to me to be neither science nor application, but misguided enthusiasm.

The principal merits of the book are that in it are assembled the findings of a great number of workers on the subject in many countries and in various branches of science and medicine; and that interspersed in the French text there are numerous summaries in English, German and Spanish, which—though not linguistic masterpieces—nevertheless greatly facilitate its perusal.

The royal jelly—named by François Huber, the famous blind entomologist—is a secretion of the pharyngeal glands of nursing bees; it is the sole food of queen larvæ and, for about three days, of worker and drone larvæ. It is now widely held that the development of sexuality and the longevity of bee queens is almost entirely due to the continued supply of royal jelly during their larval life; and on this assumption was based the expectation that human sexual drive, vigour, longevity and other positive aspects of health might be improved by the oral use of royal jelly or preparations made from it. In the author's view some of these hopes are justified. The great number of chemical analyses, biological assays and clinical reports contained in the book have, however, not convinced me that royal jelly is a particularly potent drug or that it has any unique therapeutic properties; and in spite of various ingenious hypotheses, the most I would say is that according to the data presented its uses can be described as harmless or slightly beneficial if presumably expensive.

On the other hand, it is legitimate to analyse 'bee milk' in its own right and to study the part it plays in the determination of caste and in the social life of honey bees in general; and for this the book provides much valuable information. One serious mistake on p. 331 is that Butler's queen substance is erroneously identified with the royal jelly. Also it is difficult to understand why von Frisch's experiments on polarized light and on bee language are described in Chapter 6, entitled, "Sécrétion de la Gelée royale". There is no index.

H. Kalmus

DEVELOPMENT OF SCIENCE

Histoire de la science

Publié sous la direction de Maurice Daumas. (Encyclopédie de la Pléiade.) Pp. xlviii + 1904. (Paris: Gallimard, 1957.) n.p.

This pocket-sized volume, the fifth in the "Encyclopédie de la Pléiade", is designed to constitute a complete synopsis of the historical development of the sciences from their earliest beginnings up to the most recent speculations. It has been prepared under the direction of a distinguished French scholar, M. Maurice Daumas, who, in a thoughtful preface, traces through the centuries the gradual establishment of the history of science as a recognized discipline and discusses the present organization of the subject. Confronted by the growing popular distrust of the scientist and by the competition between humane and technological ideals, he would centre education upon the theme of science conceived as a purposive human activity unfolding itself in history.

In the first of the main articles, M. Daumas follows through the ages the varying fortunes of the typical man of science—his status in society, the economic basis of his activities, and his developing techniques of investigation and communication. The next section, which deals with ancient and medieval science in all its aspects, is from the pen of the late Pierre Brunet, while Robert Lenoble, the biographer of Mersenne, analyses the vicissitudes of scientific thought in the sixteenth and seventeenth centuries. He deems the modern age to have begun with the earliest conception of a 'mathematical physics' such as Bacon never anticipated but which found full expression in the work of Galileo, the seventeenth-century advances in the techniques of experiment and calculation being motivated by, and not antecedent to, the scientific revolution.

Thereafter the several branches of science, as conventionally distinguished, are separately followed along their parallel lines of development from the sixteenth century to our own day—mathematics by the late Pierre Humbert and René Taton, astronomy by Humbert and Evry Schatzman, physics and chemistry by Maurice Daumas and Rodolphe Viallard, mineralogy and geology by Arthur Birembaut, geography by Antoine Bonifacio, the biological sciences by Maurice Caullery, and the human sciences (comprising anthropology, ethnography, sociology, demography and psychology) by Paul Lester, Paulette Marquer, Alfred Sauvy, Lucien Daumas, François Le Terrier and Gilbert Simondon.

The immense scope of the work has been attained at the cost of a severe condensation of the material, and there is no detailed documentation, although most of the sections are provided with bibliographies. The book is primarily intended to serve as a work of reference; but it should also afford the general reader a useful guide to the intricate pathways by which the sciences have attained their present levels of development.

Errors have not been entirely eliminated from the text. Joseph Priestley becomes "John Priestley" in the introduction (p. xv) although not in the body of the work; and the Doppler displacement suffered by a spectral line in consequence of the recession of the luminous source from the observer should be towards the red and not the violet end of the spectrum (p. 792). A. Armitage

PARAPSYCHOLOGY TO-DAY

Parapsychology

Frontier Science of the Mind—a Survey of the Field, the Methods, and the Facts of ESP and PK Research. By Prof. J. B. Rhine and J. G. Pratt. Pp. ix+220. (Oxford: Blackwell Scientific Publications; Springfield, Ill.: Charles C. Thomas.) 37*s*. 6*d*. net.

This book is by far the most convenient and well-designed summary of the present state of one branch of parapsychology that has yet appeared. The authors believe that the reality of extra-sensory perception (ESP) and psychokinesis (PK) is now fully established and that therefore it is time to take a general survey of the whole subject, indicating where progress has been made in the past and where it is likely to be made in the future.

The book is divided into two parts. In the first section an account is given of the facts as the authors see them and the main problems are discussed. Telepathy and clairvoyance are dealt with, and the case for psychokinesis concisely summarized. General research on extra-sensory perception is then related to that in other subjects, such as anthropology, psychology and psychiatry.

In the second part the most customary testing techniques are clearly described and the commonest statistical methods briefly outlined. The book closes with a few statistical tables, a glossary of terms and indexes to both names and subjects.

As indicated in the foreword, the plan of the book is to state the facts and in the list of authorities to refer to those publications where further information is to be sought. In the opinion of the authors the time has passed when the facts can be challenged except on the somewhat extravagant assumption of what would amount to a widespread fraudulent conspiracy on the part of the investigators themselves. A rational consistency in the expanding knowledge of extra-sensory perception is becoming more and more apparent and, as this increases, what was formerly regarded as something so extraordinary as to be beyond belief tends to become more acceptable because it is more familiar. The authors insist that the phenomena are to be seen as a means of interaction between a person and his universe or, in other words, a method of subject–object interaction. The main difference between this functioning and that on which our ordinary subject–object relations through the sensorimotor system depend, is that the operation is non-physical, although to be objectively manifested it must be converted into observable physical effect. For example, in extra-sensory perception the information acquired must be converted into some conscious experience such as a dream, intuition or hallucination.

On looking back over the past twenty-five years and then consulting this book, the reader can scarcely fail to be struck by the progress that has been made. If new to the subject, he would never imagine that many of the admirable precautions herein described have only been adopted and accepted after long and bitter controversy. Indeed, it is somewhat to be regretted that the authors have seen fit to omit in their references for further reading so many of the important papers which have been published criticizing the methods and experiments of the parapsychologists, since it can scarcely be denied that to some of these critics are due the improvements in technique that have been made.

Although the authors have been mainly concerned with the evidence for and investigation of the phenomena of extra-sensory perception and psychokinesis as seen in action with human beings, they have in more than one place suggested that the phenomena of homing, migration, etc., might be more fully understood if it were recognized that extra-sensory perception occurs and might be relevant. In this connexion they point to the cases in which, it is alleged, some domestic animal, left behind by its owners in its old home, later follows them to their new location, sometimes hundreds of miles away, where it has never been before. Certainly such a case, if properly authenticated, would provide a puzzle to any zoological student; but it is interesting to note that not a single reference is given to any fully described and documented occurrence of this kind.

Apart from occasional examples of this sort, where enthusiasm has perhaps been allowed to overstep its boundaries, the book shows a moderate and restrained attitude which is to be welcomed. As a stimulating account of work in a new and extremely complex field it can be recommended to anybody who thinks of beginning experimental work on extra-sensory perception and similar phenomena.

E. J. Dingwall

Atomic Energy in Agriculture

By William E. Dick. (The Atoms for Peace Series.) Pp. x+150+16 plates. (London: Butterworths Scientific Publications, 1957.) 15*s*.

THE title of this small book suggests an enormous field and it is fair to say that it deals with only some aspects of this, comprising almost entirely biological applications. The book is mainly a collection of notes (to which explanatory texts have been added to provide the background) of papers relevant to agriculture presented at the International Conference on the Peaceful Uses of Atomic Energy held in Geneva in 1955. It would have been of considerable assistance to the prospective buyer if this had been indicated in the title.

The largest and the most interesting chapter is on radiation genetics, which consists almost entirely of accounts of Swedish experiments and of work in the United States. The chapter on photosynthesis, although brief, shares with those on pests and forestry the distinction of being nearly as interesting as the one on radiation genetics. The isotopes oxygen-18 and carbon-14 play the principal parts in this account in elucidating (*a*) the origin of the oxygen evolved during photosynthesis, (*b*) the nature of the primary product of photosynthesis and (*c*) the metabolism of carbon dioxide through the roots. In dealing with pests, the book describes radiotracer studies on the physiology, movement and ecology of insects and animals as well as the metabolism of insecticides by insects. One rather novel use of X-rays from cobalt-60 in pest genetics is described—to produce sterile male flies of the screw-worm—which eventually eradicated this pest from the island of Curaçao. The section on forestry describes the use of bromine-82 at Wisconsin to reveal the existence of root grafts in colonies of trees. The grafts enable nutrient ions to pass from vigorous trees to weaker ones and also allows spores of fungus diseases labelled with silver-110 and iodine-131 to pass from tree to tree. The last chapter deals with the economics and technicalities of food preservation by atomic radiation and gives the reader a good idea of the problems for research which arise out of an apparently simple project. The account of work on 'other elements' attempts to deal with a vast field in a comparatively short space and fails to do full justice, except perhaps in the section on foliar application of fertilizers.

The book is well illustrated and moderately priced. Detectable errors are few; "phosphorus-35" is an obvious printer's error (p. 80) but "millicuries" instead of micro-curies (p. 68 and p. 77) are rather unforgivable slips. A bibliography of all the work referred to would have been much more useful to the reader than the rather pointless index in a book of this kind.

A Monograph on the Termitophilous Staphylinidae (Coleoptera)

By Prof. Charles H. Seevers. (Fieldiana: Zoology, Vol. 40.) Pp. 334. (Chicago, Ill.: Chicago Natural History Museum, 1957.) 6.50 dollars.

AS a systematic monograph this work is unusual in that it is concerned with an ecological unit. It comprises revisions of those groups of Staphylinid beetles which are obligatory inhabitants of termite societies. The Staphylinidae include not less than 25,000 species, mostly predators, but among them are about 300 species which live only in termite colonies. During the long evolutionary history of termites their colonies have been continually invaded by predators, including Staphylinidae, but the chance of any Staphylinid species so adapting itself to the exacting conditions of the termite society as to become established as a permanent inhabitant is very small. It is of interest, therefore, to learn that the present study of the termitophilous Staphylinidae undertaken by Prof. Seevers indicates that the present fauna of some 300 species has arisen from about six pioneer species. From each of the original successfully established species has arisen a natural group (subfamily or tribe) of termitophile species.

The rarity with which termitophile lines have been established finds a parallel in the origin of the insect fauna of remote oceanic islands. It has been pointed out by E. C. Zimmerman that in the Hawaiian Islands, for example, the present-day beetle fauna of 1,290 species is the result of the establishment of only 40 original immigrant species.

The systematic revision of the termitophilous groups, which occupies the greater part of the work, is dealt with in a thoroughly competent manner. The value of the work is enhanced by the fact that the author had available the finest collection of termitophiles in existence, that of Dr. A. E. Emerson, and was able to study all the important type material. It is perhaps to be regretted that there are few illustrations and that photographs have been used in place of line drawings. The author, however, admits this shortcoming and refers the reader to the many previously published figures. E. B. BRITTON

Introduction to Protein Chemistry

By Prof. Sidney W. Fox and Prof. Joseph F. Foster. Pp. viii+459. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 76*s*. net.

TO many readers the most valuable and interesting feature of this book will be the inclusion in one volume of an outline of the new and improved techniques for the investigation of the composition and structure of proteins and of the results obtained by their application to insulin and to a number of peptides such as gramicidin, tyrocidine, oxytocin and vasopressin. For the rest, the text largely follows the standard arrangement adopted in works on proteins. An innovation is, however, made by including a chapter on the metabolism of the amino-acids and another on enzymes. This is, in my view, a mistake. The proper setting for such subjects is in a text-book on general biochemistry, where they can be, and generally are, treated much more satisfactorily. The space devoted to a descriptive account of particular proteins and protein systems is quite inadequate. Out of a total of 459 pages only 60, of which 24 deal with the blood proteins, are employed for this purpose and of these at least two are occupied with photographs which have no instructional value. In contrast to this, no fewer than 174 pages are devoted to amino-acids and peptides. It is not, therefore, surprising that there is no proper account of the nature of many proteins such as the glycoproteins and lipoproteins; no reference to the phosphoproteins of the yolks of bird or fish eggs despite the statement that the "principal, if not sole, function" of ovalbumin is the nutrition of the young animal; and no mention of histones apart from the unexplained statement that globins "are classified as histones". E. STEDMAN

NEW ACADEMIC PRESS BOOKS

THE BIOLOGY OF HAIR GROWTH

Proceedings of the International Conference on the Biology of the Hair Follicle and the Growth of Hair held in London under the Auspices of the British Society for Research on Ageing

Edited by WILLIAM MONTAGNA and RICHARD A. ELLIS

Department of Biology, Brown University, Providence, Rhode Island

September 1958, about 525 pp., illus., 100s.

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- HERMANN PINCUS, Embryology of Hair
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- WILLIAM MONTAGNA and EUGENE J. VAN SCOTT, The Anatomy of the Hair Follicle
- OTTO BRAUN-FALCO, The Histochemistry of the Hair Follicle
- E. H. MERCER, The Electron Microscopy of Keratinized Tissues
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- RICHARD A. ELLIS, Ageing of the Human Male Scalp
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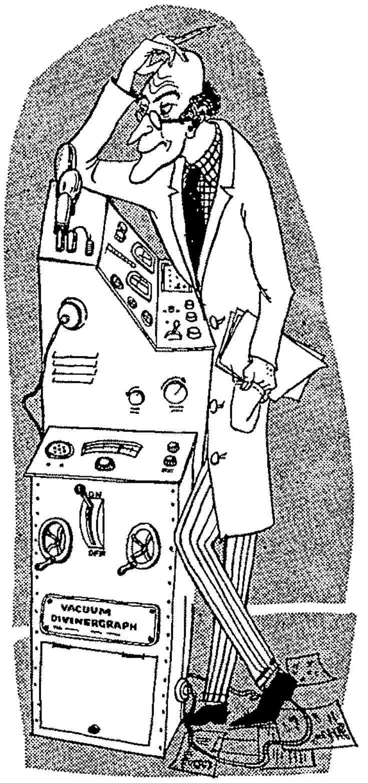

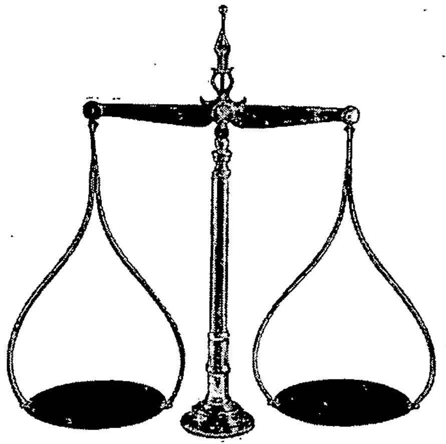

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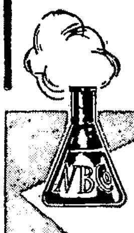

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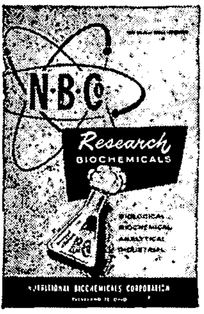

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AUSTRALIAN COMMONWEALTH DEPARTMENT OF SUPPLY: WEAPONS RESEARCH ESTABLISHMENT*

THE Australian Commonwealth Department of Supply is responsible for conducting scientific research and development in relation to war material for the Commonwealth Government in the same way as the Ministry of Supply for the United Kingdom Government. This function is performed by the Research and Development Branch of the Department of Supply, headed by the Department's Chief Scientist. The Branch operates three research establishments, two of which, the Defence Standards Laboratories and the Aeronautical Research Laboratories, are located in Melbourne, Victoria, and the third, the Weapons Research Establishment, has its headquarters located at Salisbury, near Adelaide (Fig. 1), and operates the guided weapons trials ranges at Woomera. Collectively, the staff of these laboratories, together with the headquarters scientific staff, constitute the Australian Defence Scientific Service.

The Weapons Research Establishment, formerly known as the Long Range Weapons Establishment, was instituted by the Australian Government in collaboration with the British Government. In 1946 the British Ministry of Supply considered the possibilities of a number of sites within the British Commonwealth where a range might be established with adequate supporting facilities for testing guided weapons. The requirements included a range upward of a thousand miles long, over reasonably accessible terrain, without danger to established populations, and with adequate assurance of security. In addition, supporting laboratories and workshops and associated industry were required to be available on a substantial scale. Of the various countries considered, Australia appeared the most promising, and this was confirmed by the report of an exploratory party which the Ministry of Supply sent to Australia in the same year.

In the subsequent agreement between the two Governments, Australia undertook to finance, build and operate the range system now established at Woomera and to set up at Salisbury, some three hundred miles to the south, a centre from which the work could be directed, with adequate laboratories and other scientific and technical support for the range activities. Great Britain would be responsible for the overall policy of guided weapon development and would undertake the basic guided weapon research and development; she would supply the various weapon prototypes for trials, and would undertake their subsequent production.

The accommodation Australia has provided includes workshops for the use of United Kingdom firms which are contractors to the Ministry of Supply for the development of the various guided weapons and which test them on the ranges. At present, some ten firms from among Britain's leading aircraft and electronic manufacturers are established within the premises of the Weapons Research Establishment.

These firms, and much of the joint project activities, rely a great deal for the movement of equipment and personnel on an air ferry service operated by Royal Air Force Transport Command between Lyneham, Wilts, and Edinburgh Airfield, Salisbury, which is part of the Salisbury Establishment. Aircraft, mainly 'Hastings' and 'Comets', supplemented by chartered aircraft, provide a service at about weekly intervals.

Within the Weapons Research Establishment the scientific staff is divided into two wings, one of which is concerned with trials and instrumentation requirements arising from the guided weapons programme, and the other with research and development in fields of aerodynamics, electronics and rocket propulsion for the Australian defence departments.

Each series of guided weapons trials begins with the planning of the facilities that will be required to carry them out. Although much can be done by correspondence between the United Kingdom and Australian technical establishments involved, it is usual for the requirements to be specified in a document which results from round-table conferences in the Weapons Research Establishment, to which the Ministry of Supply and the contracting firms send representatives. The provision of these facilities follows according to the agreed time-table, and later the weapon prototype arrives from the United Kingdom in the charge of technical staff responsible for the trials. Together with Establishment staff, this team produces a detailed specification of all aspects of the individual trials that are to be done, and this is forwarded to the resident staff for implementation.

Many of these trials require the co-operation of aircraft for a variety of purposes, including the provision of pilotless target aircraft. These services are provided by the Royal Australian Air Force Air Trials Unit, which operates from Edinburgh Airfield and Woomera, with headquarters at Edinburgh Airfield, Salisbury. Two airfields have been provided at Woomera. One of them, Evetts Field, is located adjacent to the range head for the operation of the target aircraft ('Jindivik', 'Meteor' and 'Canberra').

Woomera is a town of some 3,000 inhabitants 300 miles to the north-west of Adelaide. It can be reached by rail, road and air, and is maintained in arid surroundings by a water pipe line from the River Murray about 400 miles away. Despite its location, the amenities of living have been provided on a scale which is generally acceptable, and no real problem is encountered in persuading staff to undertake terms of duty there.

The associated testing ranges are laid out over a large tract of country. The main missile range starts from a point some 25 miles from Woomera town and extends in a north-westerly direction to the far coast of Western Australia about 1,250 miles away. Longer range firings to points beyond the coast can be

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* Communicated by W. A. S. Butement, O.B.E., Chief Scientist, Department of Supply, Melbourne.

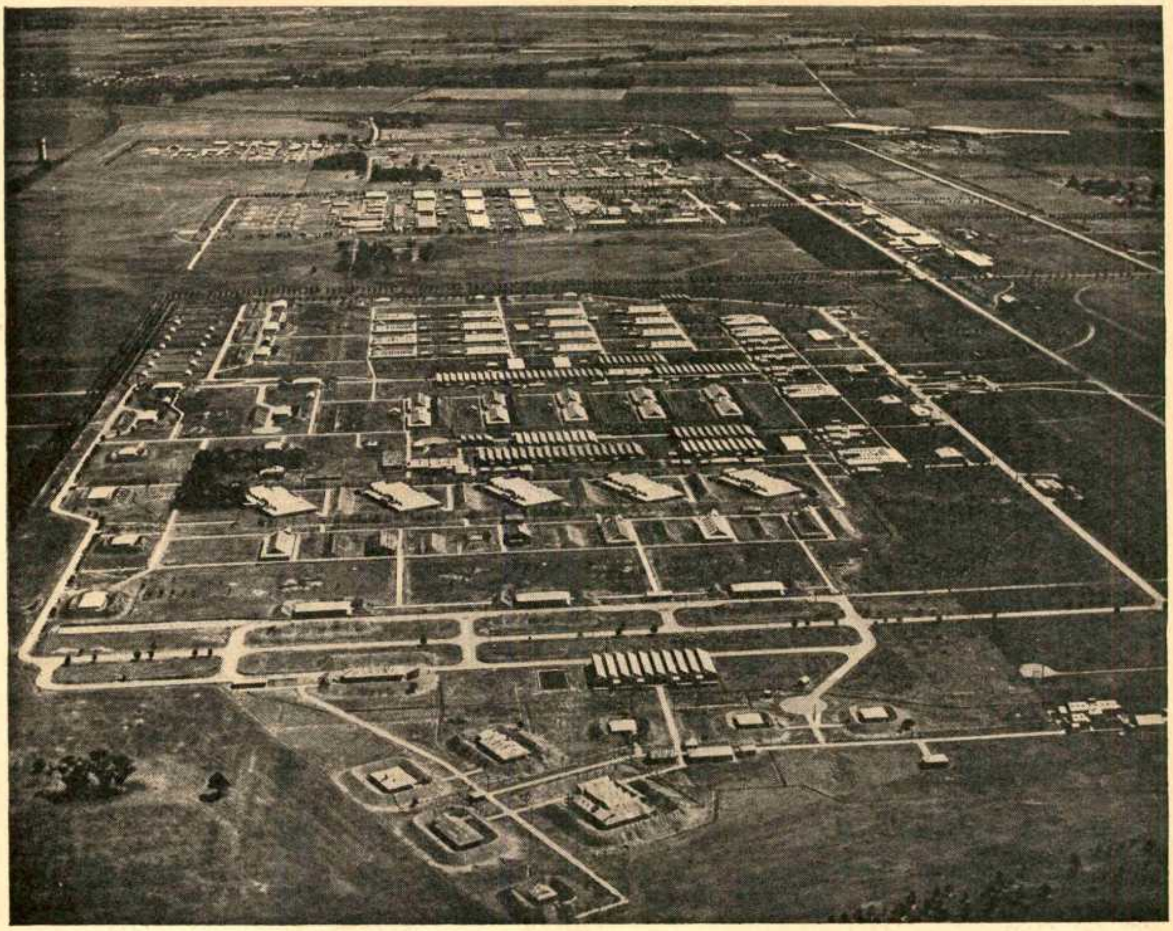

Fig. 1. Aerial view of the Weapons Research Establishment, Salisbury, South Australia

conducted as required. The whole of the territory near the firing line is virtually uninhabited barren country with no large centres of population nearby.

The actual conduct of a trial once the preparation phase is ended is a swift event at any one location, but extends over many miles of territory. This necessitates suitable deployment of the range instrumentation and its maintenance in a state of high reliability and effectiveness.

The quantities to be measured in these trials are concerned with events occurring within the missile itself during flight, with the response of the missile to manipulation of its guidance and control systems, with its trajectory and attitude during flight, and with the performance of its homing system, accuracy of engagement of target, and so on. The apparatus required to effect these measurements includes various forms of telemetry and internal recorders, and ground-based optical- and radio-tracking and velocity-measuring equipment. For many purposes the subsequent recovery of the rocket is a valuable aid to a diagnosis of its behaviour. The ability to make such recoveries is one of the outstanding advantages of ranges over land, and has been exploited at Woomera in a number of ways which in special cases ensure that missiles will neither be lost nor badly damaged.

Among the optical systems in use on the ranges are tracking kine-theodolites (Fig. 2), which record the position of the missile on successive frames of film as a basis for trajectory determination, and large fixed photo-theodolite cameras which, by a series of exposures of a single plate, enable the height and ground-speed of high-flying vehicles to be measured with great precision. In addition, high-speed cine-cameras fitted with telephoto lenses, and carried in power-operated mounts for smoothness of tracking, enable changes of attitude and performance to be examined at selected points along the trajectory. Highly specialized ribbon-frame cameras have been developed for measurements of velocity and acceleration in the early stages of flight. The determination of miss-distance between a missile and target is obtained either from ground photography or from a system of cameras carried in pods at the wing tips of the target aircraft. These cameras have unique properties which include wide-angle lenses with angles of view exceeding 200°, a pair of them providing complete cover of the volume of sky surrounding them.

The electronic instrumentation includes a missile tracking system in which a radiating oscillator is carried in the missile, and a number of auto-follow ground receivers deployed along the range transmit angular information to centralized automatic plotting tables. Various radars and continuous wave apparatus for the measurements of velocity by Doppler methods are also used. A large effort is concentrated in multi-channel telemetry which provides detailed records of the internal operation of the missile during flight.

From this multiplicity of optical and electronic equipment a vast amount of magnetic tape, film and paper is accumulated, on which the events of the trials are recorded. A data reduction system has been developed and installed at the Salisbury Establishment, based upon a large digital computer called WREDAC, which can process this data at high speed. So far as possible, records are obtained from the ranges on magnetic tape which may be fed into the data reduction machinery directly. In the case of film records, semi-automatic film readers are used for enabling the records to be transformed into forms suitable for mechanical computation with the least possible delay.

In June 1957 a conference on data reduction and automatic computing machines was held at the Establishment and attended by delegates from the United Kingdom and the United States, at which the capabilities of this system of data reduction were demonstrated and a wide range of allied subjects was discussed. Proceedings of this conference are shortly to be published by the Establishment.

A continuous effort is maintained in the investigation of techniques of measurement and recording, and the analysis of the physical processes occurring in trials work ; also in the development, manufacture and utilization of equipment and systems of apparatus for use on the ranges. Effort is also devoted to the investigation of complete missile systems and guidance and control systems both through field experiments and theoretically, the latter with the use of analogue computers. Several analogue computers are in use in the Establishment, including a general-purpose machine of high accuracy called AGWAC.

Research and development work of this nature requires substantial and versatile engineering support. The workshop organization at the Weapons Research Establishment is therefore extensive. The civil engineering work required in the construction at the ranges is carried out under the direction of the Commonwealth Department of Works in accordance with plans and specifications prepared to meet the general specifications of the scientists and engineers at the Weapons Research Establishment.

To facilitate the close liaison needed between the United Kingdom and Australia in the planning of this joint undertaking, the Ministry of Supply has established a nucleus of staff in the Melbourne head office of the Department of Supply adjacent to the latter's Research and Development Branch. A detachment of this United Kingdom staff is also established within the Weapons Research Establishment at Salisbury.

The major part of the activities of the Weapons Research Establishment is thus concerned in the equipping and operating of the missile ranges at Woomera in step with the needs of a continuing and growing activity in British guided-weapon development. The Australian defence organization also has a need for scientific research and development, and

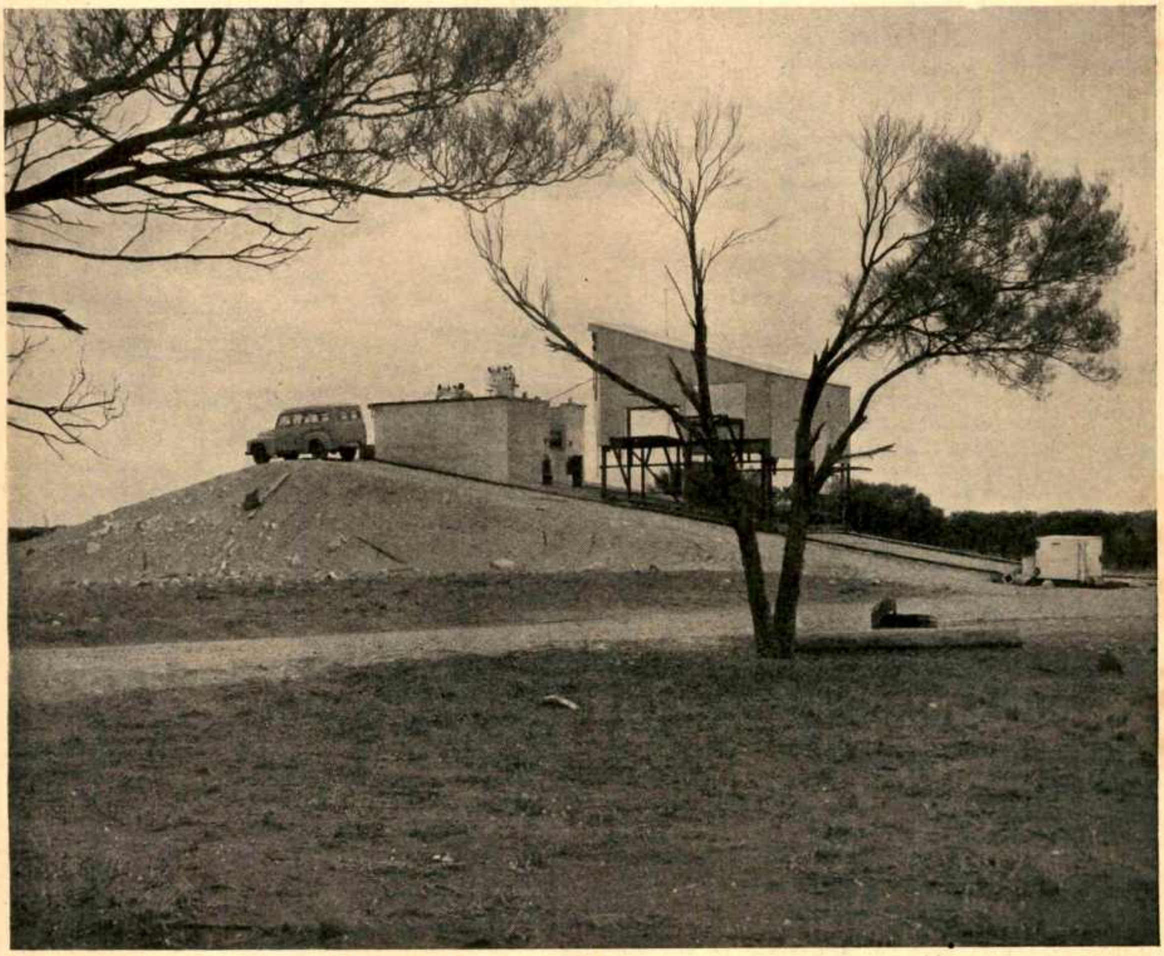

Fig. 2. A kine-theodolite post on the Woomera Range with sliding cover removed ready for use of the theodolites

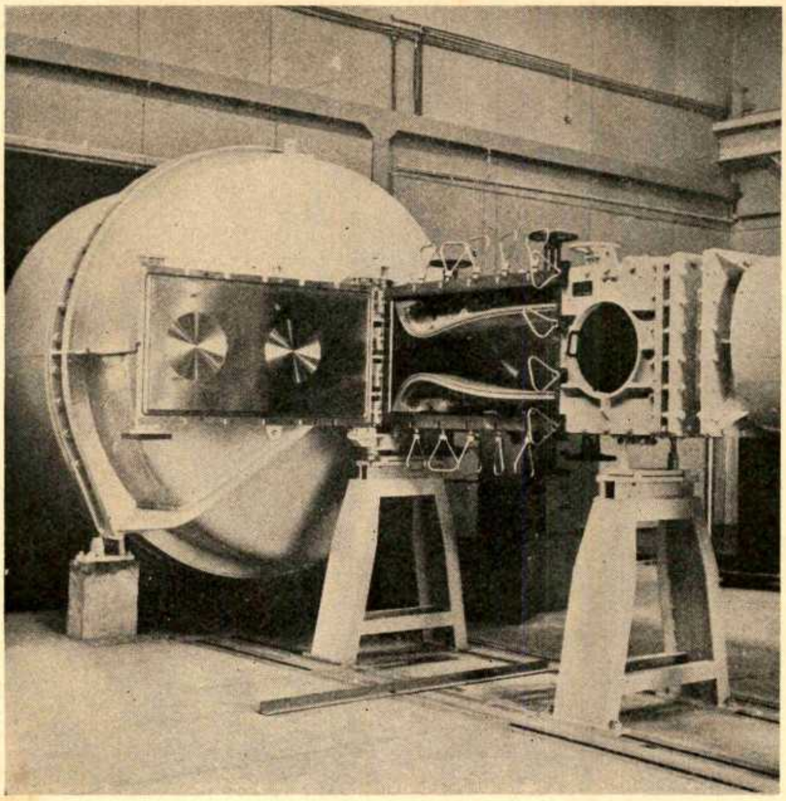

Fig. 3. 15-in. square working section of wind tunnel for Mach numbers 1·4–2·8

this is partly met by the other laboratories of the Weapons Research Establishment.

Research and Development

In Australia, defence science dates in the main from the Second World War. Prior to this, with the exception of the Munitions Supply Laboratories, there was no particular organization equipped to deal with the scientific aspects of warfare, and consequently when the emergency arose the Council for Scientific and Industrial Research, the universities and various industrial laboratories all contributed to provide the scientific effort required.

With the setting up of the Long Range Weapons Establishment in 1947, there evolved the concept of an Australian Defence Scientific Service incorporating also the Defence Standards Laboratories (formerly the Munitions Supply Laboratories) and the Aeronautical Research Laboratories (formerly a division of the Council for Scientific and Industrial Research), to undertake scientific work of a military nature. Certain other specialist laboratories also established in South Australia were incorporated into the Long Range Weapons Establishment in 1955 to form the present Weapons Research Establishment. The scientific staff of these three major establishments and the Research and Development Branch of the Department of Supply now constitute the Australian Defence Scientific Service. The Establishments are controlled by the Research and Development Branch under the direction of the Chief Scientist of the Department of Supply.

The research fields in which the Weapons Research Establishment research and development laboratories are engaged are high-speed aerodynamics, electronics and rocket propulsion. Jointly these laboratories now comprise the Research and Development Wing of the Weapons Research Establishment and are engaged primarily on research projects originated within Australian defence organizations.

The high-speed aerodynamics research is centred in two main facilities, the Woomera Rocket Range and two supersonic wind tunnels at Salisbury. There are many problems for which the free-flight technique offers particular advantages, and the facilities available at the Woomera range for this type of work are being exploited. The range is fully equipped with optical instruments for observing behaviour and tracking, with Doppler radio for velocity and, by differentiation, acceleration measurements, and with ground receiving stations for recording telemetered information from airborne transducers. Projects undertaken on the range have included the investigation of aerodynamic characteristics of rocket-boosted free-flight models, the investigation of the transonic 'area-rule', drag of wing plan-forms at transonic speeds and the flutter characteristics of rectangular wings with various mass distributions.

The 15-in. square continuous flow tunnel (Fig. 3) has a Mach number range of 1·4–2·8 and absorbs 4,000 horse-power under maximum load. The tunnel is equipped with schlieren and shadowgraph for flow visualization and multi-tube manometers for pressure measurement. Aerodynamic forces and moments acting on the model and their changes with varying incidence are measured by strain gauges and recorded in form suitable for analysis by the digital computer WREDAC. The tunnel has been in operation since March 1957.

A small 6-in. square blow-down intermittent supersonic wind tunnel for Mach numbers of 4 or slightly higher with 20 sec. duration of flow is also available.

These tunnels are used for *ad hoc* investigations and for general aerodynamic research, including the measurement of aerodynamic derivatives.

In the field of electronic research, sections are engaged in aspects of electron physics, circuit research, electro-mechanical models, and propagation studies. Applications of the non-magnetic mass spectrometer, for example, to the determination of the composition of the upper atmosphere, are being studied.

Other investigations conducted under the general heading of electronic research include the operation of double-cavity klystrons in the generation of power at micro-wave frequencies, and experiments with methods of reducing the band-width required for transmission of intelligible speech. There appears to be a possibility of achieving a band-width compression ratio of 6 to 1 with a comparatively simple system. Solid-state studies involving materials such as cadmium sulphide and amorphous selenium are in progress, with the view of their application to storage devices similar in mechanism to vidicon, but not requiring an electron beam or evacuation. The development of infra-red detectors combining sensitivity and short time-constant, particularly for wavelengths of the order 10 μ, and their use in image converters, is being studied.

In the field of chemistry also a considerable range of research and development projects is covered. Studies of the combustion of propellants for rocket motors employ the techniques of flash photolysis and shock-tubes for analysing the chemical reactions occurring and investigating the improvements to the properties of propellants. These properties, and the performance of the motors in which they are burnt, are further tested by static firings in which the thrust and the temperatures and pressures occurring within the motors are measured and recorded by a combination of optical and electronic instrumentation. The high temperatures which occur in these motors require the selective use of materials to withstand them with adequate margins of strength. Materials of the 'cermet' class are being developed for this purpose; the laboratory is equipped with the high-temperature furnaces suitable for the production of such materials. The methods of polymer chemistry are also being employed for the development of plastic and polymeric substances for use in both rocket motor components and propellants with improved physical properties, such as lightness and ability to withstand changes of operating temperature.

As a contribution to the work of the International Geophysical Year, the Weapons Research Establishment is launching two types of rocket for research in the upper atmosphere conducted by various outside research organizations. With radio equipment ('Minitrack') and a Schmidt camera provided by the United States, observations of artificial space satellites are being taken and transmitted to the satellite tracking centres in the United States. The Royal Aircraft Establishment of the Ministry of Supply has designed and built the rocket *Skylark*, which is capable of carrying a payload of 100–150 lb. of apparatus and instruments to heights up to 120 miles. This vehicle is being used by research groups from various universities in the United Kingdom, working under the auspices of the Gassiot Committee of the Royal Society, to investigate air temperatures, densities, winds, the ionosphere, and day and night air glow[1]. In addition, the Weapons Research Establishment is experimenting with the 'rockoon' technique, in which the rocket is launched from a balloon after being lifted to an altitude of 30,000–40,000 ft.

Although the Weapons Research Establishment is primarily engaged in work arising from the joint United Kingdom–Australian agreement for the testing of guided missiles on the ranges at Woomera, it will be clear from the foregoing that the Establishment also conducts a substantial programme of Australian research and development in the field of defence science. The overall Australian defence research effort is, of course, considerably amplified by the work of the other defence research establishments which are centred in Melbourne.

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[1] Massey, H. S. W., and Jones, F. E., *Nature*, 177, 643 (1956).

ISAAC NEWTON — CRIME INVESTIGATOR

By Sir JOHN CRAIG, K.C.V.O., C.B.

Formerly Deputy Master and Comptroller, Royal Mint

DR. ISAAC NEWTON was appointed warden of the Mint, with effect from March 25, 1696, during the great silver recoinage, in which historians from Macaulay to Profs. Temperley and Ogg give him a principal role. Their discrepant tributes are all false.

Money in England meant gold and silver coin. In principle, face and bullion value were identical. Unfortunately, grained or lettered rims dated only from the reforms of 1663, and the active silver circulation was mainly composed of worn coins struck long before by outmoded methods. Snipping a sliver of silver off their edges was organized wholesale from the reign of James II by those who handled coin in great quantities. By 1695, repeated small subtractions had robbed the silver circulation of between a third and half of its proper weight. A crisis of confidence set in; recoinage in a modern format had become inevitable.

Since the lost metal amounted in value to a year's revenue, there was a prolonged public controversy on whether it was worse to reduce the legal weights or the numbers of silver coins; whether, in fact, to devalue or deflate. A Commons Committee voted early in 1695 for a slightly disguised 10 per cent reduction of weights. Charles Montagu, Chancellor of the Exchequer, taking with the City of London the opposite view, evaded action. In the autumn, City magnates, scientists—among them Newton—and others were individually consulted. Newton, in view of a rise in the price of silver bullion since the spring, sought a reduction of coin weights by 20 per cent coupled with price control for the duration of the war[1]. His views were totally rejected; Montagu carried his own through Parliament in December.

Moreover, the enabling laws had been passed, the work begun and the Mint's machines and labourers trebled, before Newton was offered his appointment to the most dignified but least effective of the three principal offices of the Mint. Its duties were judicial and negative and it had been a sinecure for a century. Montagu's offer of it on March 19, 1696, did not suggest change. The proposition was "a good proof of my friendship. . . . The office is most appropriate for you. It is the chief officer in the Mint. It is worth £500 or £600 a year, and has not too much business to require more attendance than you may spare"[2].

The emoluments were, in fact, about £415 a year. Further, when, not pleading the letter but because other salaries in the Mint had been greatly raised for the recoinage, Newton asked for an increase for dignity's sake, the Chancellor's own department deferred decision until the recoinage was over; then, in August 1698, it gave him a lump sum[3] of £500, much the same in proportion as his colleagues.

Last, the Commons Committee on the Miscarriages of the Mint[4] explicitly stated on April 8, 1697, that the successful management of the recoinage was entirely due to the assistant master.

Newton's appointment was a piece of jobbery for a distinguished friend. Such benevolence may have been in mind for some time; it was reported in November 1695 that Newton had been appointed master[5], and in March 1696 it was rumoured that he would be appointed comptroller.

Though Newton took accommodation near the Mint in April or May, he moved in a few months to what was then the extreme west end of London, half an hour away. He retained his Cambridge professorship for the next four years. A small book of my own[6] has set out his activities then and later, but further examination shows that work arising out of coinage crimes was under-stated.

The place of a detective force was sporadically supplied by individual ministers, officials or justices of the peace and common informers, amateur or professional. So far as coinage offences were concerned, such inquiries had been run by a succession of warden's extra clerks; no warden before or after Newton touched this work. But in the May after his appointment, the extra clerk of the moment, George Macey, disappears; and then, if not before, the new warden stepped into the breach.

He was already well acquainted with the underworld by July 30, 1696, when he was summoned before the Lords Justices, the central body of government in the King's absence at the war, to unravel a complicated web of charge and counter-charge. A counterfeiter called Cooke, being condemned to death, bought a respite in May by betraying a number of other criminals and accusing one William Chaloner of theft of dies from the Mint. Chaloner, who was himself seeking a pardon for earlier misdeeds, told the justices that the officials of the Mint themselves supplied dies, tools and false guineas to counterfeiters. Scotch Robin, of the engraver's section, accused Thomas White of the thefts and fled to Edinburgh; White, already under sentence of death for a different crime, accused Hunter and offered information against other criminals.

As Newton investigated this imbroglio, one betrayal led to another until the accused on his hands rose to more than thirty. He interviewed at least half a dozen of them; apart from intermediate correspondence, he attended eight meetings of the Lords Justices, by whom he was further commissioned to examine the security system of the Mint[7]. All this was during the two months of August and September 1696. Other investigations are revealed by an entry in his expense account[8] for September 11, "paid Humphrey Hall to buy him a suit to qualify him for conversing with a gang of coiners of note in order to discover them, £5".

His appeal to the Treasury to be relieved of this attorney's work reveals that he had no assistant and that he interviewed personally prisoners and Newgate solicitors[9]. On November 17 the Treasury sanctioned an extra clerk at £60 a year on the ground of Newton's extraordinary work in detecting and prosecuting clippers and coiners, but the authority may have been anticipated, for the Lords Justices had agreed on August 26 that an assistant was needed, and the salary of Christopher Ellis, the clerk whom he chose, was paid from September quarter day[10].

Newton declared in 1697, what other evidence supports, that his activity had driven many counterfeiters out of London into the provinces beyond the reach of his agents; but the criminal work remained substantial.

The provinces were not neglected. Once at least, on June 9, 1698, he attended at the Treasury to advise on counterfeiting in Yorkshire. In September 1696 he had paid Charles Maris £44 2*s.* for services in Worcestershire and Shropshire; during the summer, another agent, Bodenham Rewse (afterwards head turnkey of Newgate gaol), was paid £34 for prosecutions in these and three other western counties; in March 1697, £40 rewarded Caleb Clark and Joseph Williams for arrests and convictions at Worcester and Exeter; in 1698, Christopher Priddick received £27 7*s.* for convicting seventeen persons out of forty-three charged[11]. Other agents were Taylor, a Holborn engraver, Benjamin Harris, and a little later, John Snow, Botiler, Robert Saker and Richard Morris, who was eventually rewarded with a post in the Mint.

The theft of Mint dies produced a Commons Committee with wider terms of reference to include all "miscarriages". Newton gave the chairman privately a draft Bill for improving the legislation against crime. Amended by the Judges, it was passed during the session[12]. Chaloner, called as a witness, repeated accusations of corruption and inefficiency. The essential reform was to put a practical all-round man in charge of the Mint. To show where this man could be found, he announced two inventions of his own to make counterfeiting impossible—a groove, enclosing a suitable design, in the edges of coins, and an extremely high relief. He undertook to adapt the Mint presses with an enormous future saving.

The Committee was favourably impressed and ordered Newton to bring tools and gear in five days time for Chaloner to demonstrate his methods. Newton, bound under oath not to disclose certain secrets of coining, refused. Neither could he admit the witness to the Mint. But he had pattern sixpences, shillings and half-crowns prepared in high relief and with grooved edges. In the light of this experiment, he assured the Committee that Chaloner's suggestions were expensive, impracticable and useless. These findings were undoubtedly correct. Nevertheless, the Committee reported bluntly on April 8, 1697, in favour of Mr. Chaloner's "better, securer and more effectual way" of coining[13].

Newton in his mortification promised to hang Chaloner, who blamed the final fulfilment of this threat on continuing rancour. It may have been so. Four long holograph memoranda in the Portsmouth collection are devoted to Chaloner[14]; Newton deals there with no other criminal with one minor exception. But the next clashes of the two were accidental.

In August, Newton was called to the Secretary of State's office to examine a suspected counterfeiter, from whom he learned that Mr. Justice Negus had been given full details on May 18 by one of the gang, John Peers, of coinage planned under Chaloner's direction with a new amalgam and improved moulds at Egham, as London had become too risky. He had Peers hauled to the Mint under arrest on August 13, 1697; but as nothing vital had yet been done, released him with a gift of 5*s.* to wait and watch. Peers's visit to the Tower, however, had been noticed, and another of the group had him arrested for counterfeiting. The angry warden visited Newgate next day and bailed out his witness. About the same time he arrested and examined without result a third member of the gang, Thomas Holloway.

On August 31 Newton was called in by the Lords Justices to advise on life or death for the counterfeiter Hicks. He trod on the heels of Chaloner and his old confederate, Aubrey Price, who had brought a ludicrous story of a Jacobite plot to seize Dover Castle, and a scheme for their own employment as Jacobite couriers, in order to compile lists of the disaffected. Newton revealed the two men's histories and was instructed to arrest them. After a protest that, though building up a capital charge against Chaloner, he could as yet only convict him of a misdemeanour, he clapped the pair in Newgate on September 4. Then Chaloner informed on Price, Price on Chaloner, and two other rogues added denunciations. The Lords Justices showed a great appetite for detail; Newton had to attend five of their meetings to help them. Finally, he asked through the Treasury whether in Chaloner's case he could go back beyond his pardon and was cynically advised by the highest legal authority to discredit the accused over the misdemeanour and proceed to the graver charges when the jury had been biased[15].

During the delay Chaloner suspected trickery, and promised the most dangerous witness against him, Thomas Holloway, £20 to move to Scotland; Newton elicited all the details afterwards. The two other witnesses recanted and Newton's case was summarily dismissed[16].

Chaloner protested to the new Parliament against this high-handed imprisonment in chains, for revelations against the Mint, of a witness before a Commons Committee[17]. A Select Committee was at once set up, on February 18, 1698. The charge of breach of privilege might have been perilous. Newton went over Chaloner's career, exposed some of his lies and defended the arrest, with dates, as unconnected with the previous Committee, but necessary to anticipate a "new and dangerous" way of coining by a notorious criminal. The Lords Justices were not mentioned. Sympathetic at first to the appellant, the Committee found in Newton's favour in terms which he complained were far too brief. Passing to other topics, they compelled his attendance on at least four days in April and May on the accounts of the recoinage[18].

Some time after July 9, 1698, Newton set up his new system of criminal records[19]. This volume contains his examinations of a very large number of criminals, but disproportionate space is devoted to Chaloner, and a number of letters are included, which is done in no other case. It may well have started with an entry a quarter way through of evidence taken against him on October 12, 1698, previous pages being left blank for retrospective entries. Newton's procedure is clear. A witness or suspect was brought before him in the Mint, sworn and questioned; Newton wrote down or dictated a summary of the answers—this is clear from occasional use of the first personal pronoun for the warden. The statement was read to the deponent, who, if necessary, qualified or extended it, and then signed or made his mark. Newton countersigned. Some time after, the accumulated statements were copied into the book. A number were certainly missed; only about half the deponents known from accounts or memoranda appear. Even so, it shows that Newton attended at the Mint for this purpose on at least 127 days from June 1698 to December 1699. The intensity rose to a climax in February 1699, when the Chaloner case was at its peak, with eighteen days attendance, ten of them in succession and including Sundays. This was the "King's business" with which Newton excused himself to Flamsteed in the famous letter of January 6, 1699.

A forgery by Chaloner of Malt lottery tickets, a kind of government premium bond, for which he was betrayed and arrested in October 1698, had nothing to do with the Mint or with Newton. Nevertheless, he collected and had transcribed all the evidence about it, and tipped the useful witnesses. Slowly at first, but much more intensely after the turn of the year, he gathered information about Chaloner's coinage crimes. He even employed in succession, one after the other, as each was seen through by Chaloner, three men whom he had committed to Newgate for crimes, to worm their way into the suspect's confidence and pass on his admissions. Stranger still, he met one of these men in a public house near the prison for oral report and instruction[20].

When after these delays Chaloner was put on trial on March 2, 1699, at the Old Bailey, the lottery ticket forgery was dropped. Newton instead laid three indictments against him: (1) that he had suborned on September 13, 1697, the witness Thomas Holloway to fly; (2) that he had made twenty counterfeit French gold coins in Middlesex on August 25, 1698; (3) that on that day and in that county he had made 10 false guineas, 20 crowns, 40 half-crowns, 20 shillings and 10 sixpences[21].

None could think that 100 counterfeits in two metals and five denominations were made in a single day. The trial proceeded on the third and only capital charge. Newton's six witnesses, all of them criminal and disreputable, were allowed to roam over the past six years without precision as to time or place. Apparently the nearest offence, and that in Surrey, was of forging some shillings in June. Common sense triumphed over the niceties of the law. The jury found Chaloner guilty and he was sentenced to be drawn on a sledge to Tyburn and hanged.

A piteous letter[22] to Newton, detailing all the irregularities of the trial and the prisoner's innocence, had no effect and Chaloner was hanged on March 22, 1699. His gift to Newton at the last moment was grotesque: it was the copper plate for forging the lottery ticket.

Newton continued these pursuits on a diminishing scale until June 1700, six months after he had become master and had been replaced by a new warden, and he resumed them for a short period in 1704. Detection may, after all, have had some appeal for him.

Seven of Newgate's inmates in March 1699 had been committed by Newton, and he probably imprisoned more than a hundred criminals in London alone. A small minority were hanged. Thirteen men and two women were executed in London for coinage offences in 1697; the total fell to eight in 1698[23]. It may be a mere coincidence that London executions for coinage offences practically ceased from 1700 for a few years. The cost was small, less than £300 a year, apart from the large statutory awards given by the Treasury. In addition, Newton was paid his bill for £120 for various small expenses, apparently personal, on coach hire and in taverns, prisons and other places during his wardenship[24].

In the light of the corruption, disorder and chaos which he had experienced, Newton evolved at an unknown date a detailed proposal for a board "above the reach of ordinary corruption" with salaried indoor and outdoor staff wholly financed by the Treasury and unconnected with the Mint, to centralize all evidence, manage all prosecutions throughout the country, and advise on all pardons. Non-co-operative justices of the peace were to be dealt with through neighbouring benches and the Lord Chancellor[25].

So sweeping and costly a change was not likely to be accepted forthwith; but Newton inserted the thin edge of the wedge in 1715 by the appointment of a solicitor in place of the extra clerk, and the prescription of a scale of fees for each type of case. The ponderous department of the Mint solicitor grew out of this germ. It established a country-wide system, and centralized co-ordination and control long before most of its work was handed over to the new police in 1851.

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[1] Manuscript volume No. 62, entitled "Recoinage of 1696", in the Goldsmiths' Library of the University of London.

[2] Letter from the Portsmouth Papers, now in the archives of the Bank of England.

[3] "Calendar of Treasury Papers", 37, 48; of "Treasury Books", 108 (1698–99).

[4] Printed in Rogers Ruding, "Annals of the Coinage of Great Britain", 2, 465 (1840).

[5] Luttrell, Narcissus, A brief relation of State Affairs, under date November 5, 1695.

[6] Craig, John, "Newton at the Mint" (1946).

[7] "State Papers Domestic", 177 ff., passim (1696).

[8] Newton MSS. in Mint Library, Vol. 1, leaf 467.

[9] Newton MSS., Vol. 1, leaf 438.

[10] "Treasury Books", 310, 325 (1693–96). "State Papers Domestic", 362 (1696), Warden's Accounts in Newton MSS.

[11] "Try Books", 106 (1697–98). Newton MSS., Vol. 1, leaf 476.

[12] 8 and 9 Will, III c. 26. Newton MSS., Vol. 1, leaf 499.

[13] Ruding, *loc. cit.* William Chaloner, "The Defects in the Present Constitution of the Mint" (1697). Newton MSS., Vol. 1, leaves 499 and 501.

[14] Newton MSS., Vol. 1, leaves 496, 499, 503, 504.

[15] "State Papers Domestic", 339 (1697).

[16] Depositions, etc., Nos. 80, 81, 98, 107 in MS. vol. in Mint Library.

[17] Newton copied out the petition (Newton MSS. Vol. 1, leaf 497), which Chaloner printed and published.

[18] Haynes, Hopton, "Brief Memoirs relating to . . . the Late Grand Coinage of 1696–9", Lansdown MS. 801, British Museum. Williams, O. C., "The Minute Book of James Courthope" (1953).

[19] A manuscript book of depositions, affidavits and letters, mainly July 1698 to December 1699, re-purchased in 1772 by the Mint Assayer from a second-hand book-seller.

[20] Depositions Nos. 130, 134.

[21] Middlesex Sessions Roll, March 1699, Middlesex Record Office.

[22] Copy, Deposition No. 205.

[23] Luttrell, under 16 dates.

[24] "Treasury Books", 200 (1699–1700).

[25] MS. in Newton's hand, Pierpont Morgan Library, New York, printed by David Eugene Smith in W. J. Greenstreet (ed.) "Isaac Newton, 1642–1727", 31–4 (1927).

EARLY WRITING IN GREECE

TABLETS of baked clay inscribed with short statements in two unknown scripts of the later Bronze Age (which in the eastern Mediterranean ended about the eleventh century B.C.) were found in Crete around A.D. 1900. Sir Arthur Evans, their discoverer, named the earlier script Linear *A* and the later Linear *B*. A few examples of Linear *B* were also recognized on the mainland of Greece, but it was not until 1939 at Pylos and 1952 at Mycenæ that the Greek finds became considerable. From the first, it was apparent that many of these tablets were accounts and the numerical system was soon worked out. The other signs number between eighty and ninety and occur in small groupings, so that it was reasonably inferred that they represented syllables and not single consonants and vowels. Though a few entries were accompanied by rough but sometimes recognizable sketches of objects (ideograms), the language was not deciphered; but since Bronze Age (or Minoan) Crete was believed not to be Greek, it was concluded that the language of both Linear *A* and Linear *B* was not Greek either.

The decipherment of the tablets by themselves, though occasionally attempted, was generally considered impossible, and indeed relatively few of them were published. But in 1952, a young British architect, Michael Ventris, who had been working on the problem over a period of sixteen years, announced a solution of Linear *B*. By studying the distribution of the signs he deduced something about the system of grammatical inflexions and the relationships between several of the syllables: if, for example, groups of signs occur which differ only in the last syllable, then there is some likelihood that those last syllables begin with the same consonant and terminate with different vowels. Next he tried to fit ancient Cretan place-names into this framework, and so obtained provisional values for some syllables. The application of these values to other words gave results that looked like Greek, and by experiment values were assigned to most of the other syllables. For the interpretation of his results, Ventris collaborated with an expert on Greek language, John Chadwick, who has continued the task after Ventris's early death. Their "Documents in Mycenæan Greek" is now a standard work.

The Greek obtained by Ventris is at first sight curious. Greek is not a language that lends itself to a syllabary of the type of one consonant plus one vowel, and so final consonants are omitted. Secondly, the deduced syllabary does not distinguish between *l* and *r*; *b* and *p* and *ph*; *g* and *k* and *kh*; or *t* and *th*: so, to take a very extreme case, *pa-te* stands for *pater* and *pantes*, and could stand for some hundreds of permutations conceivable by the rules of Greek word-structure. Thirdly, the vocabulary and grammatical inflexions differ considerably from those of the next Greek documents, composed some 500 years later in the eighth century B.C. Fourthly, the texts of the tablets, as is natural in brief notes, do not often have a normal syntactical form.

In spite of these difficulties, most classical students have accepted the solution of Ventris and Chadwick. They argue that the decipherment works, that for historical reasons Greek was probably spoken in mainland Greece in its Late Bronze (or Mycenæan) Age, when these tablets were written; that their dialect resembles Arcadian, which geography suggests was descended from a dialect spoken in Bronze Age Greece; that some of the word-forms, titles and names were to be expected from linguistic evolution and later legends; and, more cogently, that after the decipherment was published new tablets were found with sketches of objects and descriptions written beside them, and these descriptions make good sense. The disbelievers allege that the proposed rules of spelling are so elastic that Greek of some sort could be read out of almost any hotch-potch of syllables, and that even so, the transcriptions offered are barely, if at all, intelligible. Though some scepticism in detail is needed, it seems to me that in principle the decipherment is convincing.

Any new theory is likely to attract some embarrassing supporters, and many of the interpretations of the tablets are exaggerated or even silly. The tablets so far known number altogether about 5,000, and most are fragmentary. They are, when complete, flat slabs of clay in sizes generally from 16 cm. × 3 cm. to 30 cm. × 15 cm. and contain from about a dozen to 180 signs. They were used for accounts and short records and, since they were originally unfired, were not meant to be kept long. Those that survive do so by virtue of the accident that the room where they were was burnt down. From this it follows that the tablets we have do not form continuous series, but are, in fact, sets of the same date. The conclusions drawn from this unpromising material are first linguistic, secondly historical.

For the earlier development of the Greek language and changes in vocabulary the tablets are obviously important, though they give little evidence on syntax and many of the forms are ambiguous. They also explain some traditional phrases in Homer, and show that Semitic loan-words had been accepted in Greek by the thirteenth century B.C. Philologists in general appreciate the limitations of this material and their claims are reasonable.

It is very different with historical interpretations. When they speculate on periods that are not fully historical, too many classical students (and prehistorians) cultivate a fundamentally uncritical ingenuity, and the obscure hints of the tablets are a tempting bait. The favourite topics for exegesis are social classes and land tenure (on which, it seems to me, the present evidence is inconclusive) and the relation between Mycenæan society and that presented 500 years later by Homer (which is, in my opinion, tenuous). What is certain is that the ruling groups of Mycenæan Greece used the Greek language, that they worshipped most of the later Greek deities, that some of the names of personages in later Greek legends were current in Mycenæan times, and that there were Greek rulers in Late Bronze Age Crete. Some time in the future, perhaps, a longer document or treaty will turn up to provide more historical illumination. Whether the Mycenæans should be considered as Greeks is another problem, which depends partly on definition. They spoke Greek and were ancestors of the historical Greeks, but their culture was very different, antecedent to but not perhaps significant for the development of the culture which we normally mean when we speak of Greek or Hellenic.

The volume* the appearance of which has provided the occasion for this article almost completes the publication of all the tablets found up to last year. A. J. B. and E. B. Wace explain the circumstances of their finds, Bennett illustrates, describes and transcribes precisely, and Chadwick comments with careful judgment. Incidentally, there is some useful information for the history of botany. The indexes are full. The evidence is now admirably presented for other students to use or misuse.

R. M. Cook

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* Transactions of the American Philosophical Society. New Series. Vol. 48, Part 1: The Mycenæ Tablets II. Edited by Emmett L. Bennett, Jr. Translations and Commentary by John Chadwick. Pp. ii+122. (Philadelphia: American Philosophical Society, 1958.) 3 dollars.

OBITUARIES

Viscount Bledisloe of Lydney, G.C.M.G., K.B.E.

On July 3, Viscount Bledisloe died at his home at Lydney, Gloucestershire, in his ninety-first year. He was one of the first members of Parliament to take an interest in agricultural science, when rather more than fifty years ago it was breaking away from the ideas of the mid-nineteenth century that had long dominated it and began to develop on modern lines. In its earlier days, agricultural science had been largely concerned with finding solutions to farm problems; it had almost reached a dead end. The new purpose was to study the relations between the growing plant and its environment without regard to whether the results might have any bearing on agricultural practice.

Lord Bledisloe, then Charles Bathurst and member of Parliament for Wilton, was one of the few in authority who recognized the soundness of this approach. British agriculture was very slowly beginning to emerge from a severe depression that had lasted for some twenty years, and he constantly urged the Government to help it; he was almost alone in this, but he never lost heart. The Government went so far as to promote agricultural education, but would do nothing for the new type of agricultural research. He realized that agricultural education, to be effective, must be based on a sound agricultural science, and when finally the Lloyd George Development Fund was set up, out of which research could be financed, he actively supported the first expansion of Rothamsted Experimental Station in 1912. Later, as chairman of the governing body of the Station, he was a frequent visitor to the laboratories and made a point of knowing the members of the staff and the chief lines on which they were working. A new block of laboratories for plant pathology was built during his term of office. As chairman, his policy was to maintain the links between agricultural science and agricultural practice. This was acceptable to the leaders of the new science, who realized that it would inevitably become increasingly complex, and might, unless care were taken, become lost in the infinite spaces of pure science.

He was equally interested in the application of science to the improvement of animal health, and did much to ensure that the new knowledge should reach even the small farmers. One of the results has been the elimination of tuberculosis from many dairy herds and even from an entire county.

In 1928, he became chairman of the Imperial Grassland Association and took an active part in the awakening of interest, both practical and scientific, in the grasslands of the Commonwealth, which has led to remarkable developments in many countries. This work, however, he soon had to give up, as he was appointed Governor-General of New Zealand. The choice was a particularly happy one. He was peculiarly well qualified for the post, and filled it with great distinction, aided by his charming wife. His lively interest in the pastoral industry, New Zealand's chief source of wealth, based on personal knowledge and experience of livestock gained on his farm at Lydney, enabled him to meet farmers on their own ground, and his obvious pleasure in making direct contact with them greatly endeared him to them. His interest in the scientific workers and their problems was equally marked, and equally rewarded.

Lord Bledisloe will long be remembered with affection by those who were privileged to know him, and with deep respect by the many who in farms, villages or research stations had benefited by the encouragement he always gave to those trying to raise the standard of country life.

E. John Russell

Dr. Rosalind E. Franklin

The news of the death of Rosalind Franklin on April 16 came as a shock to many workers in the field of biochemistry and virus studies. It is a special tragedy when a brilliant research worker is cut off at the height of her powers and when exciting new discoveries are expected from her.

Rosalind Franklin was born in London on July 25, 1920, the elder daughter of Mr. and Mrs. E. A. Franklin. She was educated at St. Paul's School, London, and Newnham College, Cambridge, and started her scientific career after studying physical chemistry at Cambridge. Her first employment was in the British Coal Utilization Research Association, where she worked under Bangham on the colloidal properties of cokes and chars. She showed that although the total volume of the pores in the coal increases continuously with increasing temperature, their accessibility decreases, so that finally even helium molecules are unable to penetrate them.

It must have been apparent to her then that it would be impossible to reach an understanding of coals and chars without the use of X-ray diffraction methods. These she was able to acquire when she transferred in 1947 to the Laboratoire Centrale des Services Chimiques de l'État in Paris. Her three years in Paris working with Méring taught her to appreciate the value of monochromatic X-rays for low- and high-angle studies of amorphous substances where bands of indefinite intensity replace the sharp spots given by the more perfect crystals. It was, however, a combination of these analytical techniques with chemical preparatory skill that enabled her to unravel the major processes concerned with the transformation of practically all organic substances into different kinds of chars on heating. In a series of beautifully executed researches she discovered the fundamental distinction between carbons that turned into graphite on heating and those that did not, and further related this difference to the chemical constitution of the molecules from which the chars were made. These studies are of fundamental interest both for the old industry of coking and for the new one of graphite moderators in atomic piles.

Miss Franklin might well have remained in this field in which she had made her name, if she had not been more attracted to that of biophysics, where she was able to turn her newly developed skills to investigate the structure of large molecules of biological importance, particularly in nucleic acids and the viruses.

In 1951 Miss Franklin was awarded a Turner–Newall Fellowship to work at the newly established Biophysical Laboratory at King's College, London. Without any previous biological experience, but with a great grasp of X-ray techniques and their chemical implications, she arrived at a fortunate moment, when X-ray crystallography was breaking away from the more limited field of the study of regular crystals to those in which the molecules were only partially ordered, and in particular those in which the essential form was that of the spiral. Her first paper in this field was one of three in which the first was the now classical paper of Watson and Crick on the double-spiral hypothesis for the structure of deoxyribonucleic acid. In this close collaboration between the Cambridge and London schools it is difficult to disentangle all the contributions of individuals, but what Miss Franklin had to give was the technique of preparing and taking X-ray photographs of the two hydrated forms of deoxyribonucleic acid and by applying the methods of Patterson function analysis to show that the structure was best accounted for by a double spiral of nucleotides, in which the phosphorus atoms lay on the outside.

In 1953 Miss Franklin left the Unit at King's College to take up the direction of research on virus structure at Birkbeck College, London, where her work was supported first by the Agricultural Research Council and later by the United States Department of Health. Here her main study was on tobacco mosaic virus. She took up its X-ray study where it had been left in the work of Bernal and Fankuchen fifteen years before, using her improved techniques. Watson had put forward the hypothesis that the virus structure was also spiral, but one of quite a different order from that which existed in proteins and in deoxyribonucleic acid. Miss Franklin, with the help of very much better X-ray photographs than had hitherto been obtained, was able in essence to verify this hypothesis and to correct it in detail. It was at this point that the extremely fruitful co-operation began between Miss Franklin's unit and Fraenkel-Conrat at Berkeley, Caspar at Yale, and Schramm at Tübingen. Using the method of isomorphous replacement, she showed that the virus particle was not solid, as had previously been thought, but actually a hollow tube. Miss Franklin's greatest contribution to this study was to compare the radial density map of the intact tobacco mosaic virus with that of the nucleic acid-free particles, in which the protein units had been re-aggregated without the ribonucleic acid. This showed that the ribonucleic acid was not to be found in the central cavity but embedded in the protein.

It would also appear from work still unpublished at the time of her death that the ribonucleic acid is in the form of a single strand, following the spiral of the virus particle, thus being very different from the double-wound helices of the deoxyribonucleic acid of the bacterial viruses and higher organisms. The combined methods of chemical preparation and X-ray examination in the hands of Miss Franklin and her associates was a valuable, and indeed a decisive, weapon in the analysis of these complex structures.

As a scientist Miss Franklin was distinguished by extreme clarity and perfection in everything she undertook. Her photographs are among the most beautiful X-ray photographs of any substance ever taken. Their excellence was the fruit of extreme care in preparation and mounting of the specimens as well as in the taking of the photographs. She did nearly all this work with her own hands. At the same time, she proved to be an admirable director of a research team and inspired those who worked with her to reach the same high standard. Her devotion to research showed itself at its finest in the last months of her life. Although stricken with an illness which she knew would be fatal, she continued to work right up to the end. Her early death is a great loss to science.

J. D. Bernal

NEWS and VIEWS

Atomic Weapons Research Establishment:
Dr. Nyman Levin

Dr. Nyman Levin has been appointed by the United Kingdom Atomic Energy Authority to be a deputy director of the Atomic Weapons Research Establishment. Dr. Levin, who was born in 1906, graduated at the Royal College of Science, London. During 1930–40 he was with Marconi (Research and Development) and then he was seconded to the Admiralty to work with the Royal Naval Scientific Service. He transferred to the permanent staff in 1946. He was appointed superintendent of the Admiralty Gunnery Establishment in 1951. Since 1955 he has been chief of research and development to Rank Precision Industries. When he joined the Admiralty, Dr. Levin was engaged on the development of microwave valves; he started work in Bristol at what ultimately became the Services Electronics Research Laboratory. He carried out development work on microwave receivers and then was responsible for the establishment of cross-channel V.H.F. links, as part of the preparation for the invasion of Europe. This involved building a chain of stations along the south coast of Britain and confirming the reliability of V.H.F. communications over very long distances. Soon after the War ended he became head of the Instrumentation Group at the Admiralty Research Laboratory, where the underwater television technique was developed. With Rank Precision Industries he has been responsible for the development in Britain of xerography—a technique of dry electrostatic photocopying—and its applications, including the high-speed printing of computer outputs.

Theoretical Physics at Nottingham:
Prof. K. S. H. Stevens

Dr. K. S. H. Stevens, who has been appointed to the chair of theoretical physics in the University of Nottingham, was educated at Magdalen College School, Oxford, from which he won an open mathematical scholarship at Jesus College. After two years residence he joined the Admiralty Research Group at the Clarendon Laboratory in 1942 and returned to Jesus College in 1945. He was awarded first-class honours in the Mathematics Finals of 1947 and was Harmsworth senior scholar of Merton College during 1947–49. He obtained the D.Phil. degree for theoretical physics in the latter year. During 1949–53 he was research fellow of the Pressed Steel Company at Oxford, and during 1953–54 was in residence at Harvard University. Dr. Stevens was appointed reader in theoretical physics in the University of Nottingham in 1953. His main interests at Oxford were in the theory and magnetic properties of ionic salts, and more recently he has been concerned with the ferromagnetism of metals and alloys and other aspects of magnetism, including applications to micro-wave amplifiers.

Agriculture at Nottingham:
Dr. J. D. Ivins

The appointment of Dr. J. D. Ivins to the chair of agriculture at the University of Nottingham, vacant since the resignation of Prof. H. G. Robinson in 1954, will be welcomed by his friends throughout the United Kingdom. Dr. Ivins graduated from the University of Reading with honours in agricultural botany in 1944, and was appointed almost immediately to the National Institute of Agricultural Botany at Cambridge. His connexion with the University of Nottingham was made in 1945, when he went as crop recorder to the School of Agriculture at Sutton Bonington. He became lecturer in crop husbandry in 1948, and was invited to become acting head of the Department of Agriculture in 1955. Dr. Ivins has been an active member of the Agricultural Education Association and of the British Grassland Society, and since 1956 has been recorder of Section K of the British Association. An able and inspiring lecturer, he has already made noteworthy contributions to the welfare of the School, in the reorganization of the University farms, and by the extensive and effective liaison he has built up with numerous sections of agriculture and its related industries. At the same time he has developed and encouraged an effective school in the Department of Agriculture, where he has initiated two lines of research. The first, which arises logically from the theme of the Nottingham School, is the effect of cultural practices on the growth of the potato crop. The second, which is more peculiarly his own, is an attempt to bridge the gap between crop and animal husbandry by a study of the utilization of grass by the grazing animal. His use of small balanced herds of identical twins has given a precision to measurement that has not hitherto been possible, and the more critical evaluation of pasture productivity that results affords interesting potentialities for the future.

Chair of Heat Transfer in London:
Prof. D. B. Spalding

Dr. D. B. Spalding, whose appointment to the new University chair of heat transfer tenable at the Imperial College of Science and Technology, London, has just been announced, is well known for his work in the general field of thermodynamics and heat transfer. His research interests in the past few years have been concerned in particular with problems of temperature distribution and heat transfer in combustion processes, and with the thermodynamics and mass transfer in boundary layers, particularly in high-speed flow. He has developed and exploited a number of analogue methods for the solution of the equations that arise in these connexions, some of them electronic and others mechanical analogues in the true sense. His new appointment marks a further stage in the planned expansion of the Mechanical Engineering Department at the Imperial College of Science and Technology, as the completion of the first stage of the new Engineering block makes available some more room for experimental work in heat transfer.

Royal Commission for the Exhibition of 1851: Awards for 1958

The Royal Commission for the Exhibition of 1851 has awarded the following senior studentships for 1958 for research at the universities indicated: Miss I. C. Gardner (Glasgow), for research in plant biochemistry; P. B. Jones (Oxford), for research in nuclear physics; M. P. Kerney (Imperial College of Science and Technology, London), for research in palæontology; G. W. Kirby (Cambridge), for research in organic chemistry; P. A. G. Scheuer (Cambridge), for research in radio astronomy. The Commission has also awarded the following overseas scholarships for 1958: I. G. Macquarrie (Dalhousie University), for research in botany at King's College, London; E. A. Ogryzlo (McGill University), for research in physical chemistry at Sheffield; W. R. Frisken (Queen's University, Kingston), for research in nuclear physics at Birmingham; D. W. Cameron (University of Queensland), for research in organic chemistry at Manchester; D. H. Green (University of Tasmania), for research in geology at Cambridge; R. M. Freeman (University of New Zealand), for research in physics at Cambridge; Miss A. J. Alexander (Rhodes University), for research in zoology at Cambridge; M. E. Mitchell (National University of Ireland), for research in ecological botany at the University of Rennes; G. B. Venkata Subramanian (University of Delhi), for research in organic chemistry at Cambridge; M. M. Islam (University of Dacca), for research in physics at Birmingham.

The National Chemical Laboratory

THE Lord President of the Council has approved changes in the functions of the Chemical Research Laboratory at Teddington, Middlesex, proposed by the Council for Scientific and Industrial Research, and the name of the Laboratory has been changed to the National Chemical Laboratory. The Laboratory will concentrate its effort on a few objectives, covering only a limited part of the whole field of chemical research, so as to be able to make a real impact on selected problems of national importance such as the following: (*a*) Problems which are appropriate neither to industrial research laboratories nor to universities, because of the necessity for special facilities, experienced staff and continuity of effort. These include the determination of the fundamental physico-chemical properties of chemical compounds which are required, for example, by chemical engineers for the design of full-scale industrial plant. The related study of the development of techniques of purification of materials such as metals and chemicals, with the view of supplying standard samples of pure substances for reference purposes, is also in this category. (*b*) Problems, the solutions of which are of national economic value and have wide general applications to many industries, for example, fundamental and applied studies of the corrosion of metals, which has been estimated to cost Great Britain about £600 million a year. (*c*) Problems, the solutions of which are urgently required in connexion with the nation's atomic energy programme; these are mainly concerned with the extraction of elements of atomic energy interest from low-grade ores. The change in the name to the National Chemical Laboratory has been decided upon to emphasize that its main purpose will be to undertake selected fundamental and applied chemical researches of national importance, which could not otherwise be worked on by any existing organization.

Windscale Pile No. 1

THE Atomic Energy Authority has decided that it would not be economic to repair Windscale Pile No. 1. The maximum technical information which can be derived from examination of the reactor core is being obtained, and useful materials and equipment will be recovered. Some of the buildings will be adapted to other uses and the remainder sealed off. The operatives hitherto employed on this reactor are now engaged on other activities at Windscale which are expanding.

Moral Implications of Atomic Energy

IN his Burge Memorial Lecture delivered on April 15 at Church House, Westminster, which has now been published ("Ethical and Political Problems of the Atomic Age". Pp. 22. London: Student Christian Movement Press, 1958. 2*s*. net), C. F. von Weizsäcker discussed some ethical and political problems of the atomic age, as a scientist, as a citizen of the Western world and as a Christian. Beginning with the observation that the most conspicuous political event of 1957 was the appearance of the first Soviet Earth satellite, he points out that this technical achievement became a political event because of its psychological effect, and that such developments pose the problem of the adult man, no longer protected like a child, who can survive only if he creates for himself the conditions of life. Dr. von Weizsäcker himself believes that the spiritual foundations of the technical world are dependent upon Christianity. Pointing out that Western freedom is guaranteed only by the certainty that mortal blow will be answered with mortal blow, he maintains that this is a very precarious guarantee. After examining the measures proposed for avoiding the present dangers, he concludes that, in principle, it would be sensible to strive for the total abolition of war by all prudent means and that such attempts have a good chance of success. It is, however, the policy of the Soviet Union to undermine the strength of the West by exploiting the prevalent and understandable antipathy to nuclear weapons. The belief that such weapons will effectively protect our peace and freedom is itself a well thought-out ideology containing strong elements of truth, but its effect is to cripple our wills. Dr. von Weizsäcker does not think that the Church as an institution is in a position to suggest the renunciation of the hydrogen bomb on a basis of political responsibility; those who have already experienced something of this crisis would render their fellow-men a service by dissociating themselves from all participation in matters connected with such weapons. The value of passive resistance and of more conventional political methods requires much fuller examination.

Preservation of Rural England

THE twenty-seventh annual report of the Sheffield and Peak District Branch of the Council for the Preservation of Rural England, presented at the annual meeting on May 31, stresses the failure of Parliament to respond to the urgent plea that the Land Fund, understood to be designed for National Parks, should be put to that purpose. In consequence, the National Parks Act is ineffectual, and the same lack of vision, the report urges, is shown in the siting of nuclear power stations in the very areas the National Parks Act was framed to protect. The Branch fully supports the stand being made against the proposal to site such a station on Trawsfyndd Lake. Tribute is paid to the competent control constantly exercised by the Park Planning Board in the Peak District National Park, and the Board and the Branch are supporting the petitioners against the proposed Chew Valley reservoir, which would take all the remaining farmland and spoil the fine approaches up the Chew Valley to the moors of the National Park. With the National Parks Commission and the National Trust, the Council and its local branches have indicated their opposition to the proposed motor road in the Manifold Valley. Adverse comment is also made on the proposal to erect a steel lattice-tower 150 ft. high for a police radio transmitter and on the continuance of threats from opencast coal-mining, notably at Barlow. However, the arrangement between the General Post Office and the Peak Park Planning Board covering the whole Peak regarding proposals likely to affect the landscape, and of the Sheffield Corporation's policy towards tree planting, receive favourable mention.

International Certification of Herbage Seed

As a result of a certification scheme introduced by the Organization for European Economic Co-operation, the farmers of Europe will in future be able to rely on the qualities and types of seed for grasses and legumes offered for sale. In the past, confusion has arisen due to differences in nomenclature and methods of certification between countries. Hitherto, herbage seed offered in international trade has fallen into two categories: uncertified seed and seed certified in accordance with various national systems. The effect of the new rules and directions approved by the Organization for European Economic Co-operation is the introduction of a third category—herbage seed bearing an international certificate and a special label issued under the authority of the official seed-certifying agencies in member countries of the Organization. The scheme is open to any of the seventeen member countries and will operate for an initial period of five years. Copies of the rules and directions can be obtained from the Director of Agriculture and Food of the Organization for European Economic Co-operation.

Colleges of Technology in Britain

In a written answer in the House of Commons on June 18, the Minister of Education, Mr. Geoffrey Lloyd, listed the following colleges as approved, up to the present, as colleges of advanced technology: Birmingham College of Technology; Bradford Institute of Technology; Battersea College of Technology; Chelsea College of Science and Technology; Northampton College of Advanced Technology; Loughborough College of Technology; Salford Royal Technical College, and the Welsh College of Advanced Technology, Cardiff. Those approved as regional colleges are: Brighton Technical College; Bristol College of Technology; Brunel College of Technology, Acton; City of Liverpool College of Building and City of Liverpool College of Technology; Glamorgan College of Technology, Treforest; Huddersfield College of Technology; Kingston-upon-Thames Technical College; Leicester College of Technology and Commerce; North Staffordshire Technical College, Stoke-upon-Trent; Nottingham and District Technical College; Plymouth and Devonport Technical College; Portsmouth College of Technology; Rugby College of Technology and Arts; Sunderland Technical College; West Ham College of Technology; and in London, the Borough Polytechnic, Southwark; Brixton L.C.C. School of Building, Lambeth; Northern Polytechnic, Islington; Sir John Cass College; The Polytechnic, St. Marylebone, and Woolwich Polytechnic.

Imperial Cancer Research Fund

The fifty-fifth annual report of the Imperial Cancer Research Fund for 1956–57 (pp. 45. London: Imperial Cancer Research Fund, 1958), besides its survey of current work, refers to the approval of plans to build in Lincoln's Inn Fields, London, new and adequate laboratories adjoining the Royal College of Surgeons. The initial building costs are estimated at £600,000, and about £250,000 will be required for furnishing and equipping the laboratories, with an additional annual £150,000 for maintenance. The new research laboratories will provide accommodation for the chemico-pathological research at present being carried out at No. 48 Lincoln's Inn Fields, but will also permit a big expansion in the research programme of the Fund. Current work at Lincoln's Inn Fields is concerned mainly with the relation between hormones and human cancer, concentrating on cancer of the breast and of the prostate. An important part of the service there is the work on the early diagnosis of cancer by the study of smears of secretions. At the Mill Hill Laboratories fundamental biological research is largely concerned with tumour growth in animals and the characteristics of various malignant tumours. Dr. J. Craigie has perfected a method for storing tumours in a frozen state at – 32° C. for four to seven years, and human tumours, removed at operations or at post-mortem examinations, are being transplanted into laboratory animals so that the effect of different agents on cell growth can be observed. The reaction of tumour cells to changes in environment is being studied with an ingenious kinemicroscope with 'Perspex' observation chambers. Lists of papers published from the Laboratories since the last annual report are included in Dr. Craigie's and Prof. G. Hadfield's reports on the work of the Laboratories.

Soviet Crystallographic Meeting

The sixth general meeting called by the Commission for X-ray Diffraction of the Academy of Sciences of the U.S.S.R. was held in Leningrad during June 23–29. Some 900 people, including ten foreign guests, attended the opening session, which was addressed by the chairman of the Commission, Prof. G. S. Zhdanov (Moscow). The meeting proceeded in seven sections devoted to the X-ray study of alloys; X-ray studies of deformed metals; X-ray structural analysis and crystal chemistry; apparatus and methods of X-ray structural analysis; X-ray spectroscopy; electronography; and X-ray and γ-ray defectoscopy. The total number of papers contributed in these specialized sections was 333, and in addition there were twelve contributions during the full sessions. The rapid growth of crystallographic research in the Soviet Union is evident from this meeting, and from the reported production of sealed X-ray tubes in the U.S.S.R., namely, 3,887 tubes in 1957 and 4,700 in 1958. After the meeting most of the foreign guests travelled to Moscow and had opportunities of seeing the crystallographic work in progress in various institutes.

Travelling Fellowship and Student Prizes in Psychiatry

Mr. J. A. Baldwin, a medical student at the University of Aberdeen, has recently been awarded the first of the Mental Health Research Fund Travelling Fellowships. These are awarded annually to medical students, selected by an essay competition and interview, by the Mental Health Research Fund (39 Queen Anne Street, London, W.1), for special training in psychiatric or other departments abroad for six months. The Fund hopes in this way to stimulate interest in mental health and, particularly, in research bearing upon it, at an early stage in the student's career. The subject of the essay was "The Relative Importance of Nature and Nurture in the Development of Psychiatric Disorder". In addition to the Travelling Fellowship, three cash prizes have been awarded: £100 to Dr. G. Sedman, Manchester Victoria Memorial Jewish Hospital; £50 to Mr. J. D. Swales, Westminster Medical School; and £25 to Mr. A. P. K. John, Pembroke College, Oxford.

Institution of Civil Engineers

The following were recently elected to office in the Institution of Civil Engineers: *President*, Prof. A. J. S. Pippard; *Vice-Presidents*, A. C. Hartley, Sir Herbert Manzoni, Sir George McNaughton, R. W. Mountain; *New Members of Council*, L. Carnie (Glasgow and West of Scotland), N. S. Cox (South Western), A. Dean, S. E. Faber (Colonies), J. R. Farquharson (Colonies), J. T. D. Firth (North Western), O. Holden (Canada), W. P. F. McLaren (South Africa), T. P. de S. Munasinghe (Ceylon), R. H. Roberts (Northern and Southern Rhodesia), J. F. Stanbury, R. W. Taylor (Colonies).

University News: The Queen's University, Belfast

The following appointments have recently been made in the Queen's University of Belfast: Dr. G. Seth, to the chair of psychology; Dr. H. G. Heal, to a lectureship in inorganic chemistry; Mr. T. K. Marshall, to a lectureship in pathology (forensic medicine).

Birmingham

The following appointments in the University of Birmingham have recently been announced: Prof. D. L. Linton, professor of geography in the University of Sheffield, to the chair of geography, made vacant by the retirement of Prof. R. H. Kinvig, from October 1; Dr. P. J. Hilton, senior lecturer in mathematics in the University of Manchester, to the Mason chair of pure mathematics, made vacant by the resignation of Prof. C. A. Rogers, from October 1; Mr. I. T. S. Essery, to be senior lecturer in civil engineering; Mr. D. M. G. Wishart, to be lecturer in statistics in the Department of Pure Mathematics; Dr. J. D. Young, to be lecturer in physics; Drs. K. J. Morgan, R. S. Lehrle and J. D. Hobson, to be lecturers in chemistry; Dr. R. E. Smallman, to be lecturer in physical metallurgy; Mr. G. R. Coope, to be lecturer in geology; and Mr. N. Dennis, to be lecturer in sociology. The title of reader in mathematical physics has been conferred on Dr. G. E. Brown, lecturer in mathematical physics, from October 1.

Bristol

The following appointments in the University of Bristol have recently been announced: Mr. J. M. Cook, reader in classical archæology in the University, to a chair of ancient history and classical archæology; Dr. J. W. F. McOmie, to a readership in organic chemistry; Mr. R. W. Marsh, to a readership in plant pathology; Dr. Suzanne K. R. Clarke, to a lectureship in bacteriology.

London

The title of professor of pure mathematics in the University of London has been conferred on Dr. K. A. Hirsch, and that of professor of zoology on Dr. G. E. Newell, in respect of their posts at Queen Mary College. The following University appointments have also been made: Mr. A. Stuart, to the readership in statistics tenable at the London School of Economics and Political Science; and Dr. E. Cotchin, to the readership in veterinary pathology at the Royal Veterinary College.

Announcements

The Société Mycologique de France and the British Mycological Society are holding a joint foray at Reading during September 3–10. Further information can be obtained from Dr. F. B. Hora, The University, Reading, Berks.

A symposium on "Salinity Problems in the Arid Zones", organized by Unesco, will be held in Teheran during October 11–15. Further information can be obtained from M. Batisse, Arid Zone Unit, Department of Natural Sciences, Unesco, 19 Avenue Kléber, Paris XVI^{e}.

The annual conference of Aslib will be held at the University of Nottingham during September 5–8. Members are requested to register not later than August 22. Further information can be obtained from Aslib, 3 Belgrave Square, London, S.W.1.

The Institute of Rural Life at Home and Overseas is holding a course of rural studies at the Essex Institute of Agriculture, Writtle, near Chelmsford, Essex, during August 31–September 13. Further information can be obtained from the Institute, 159 Bryanston Street, Marble Arch, London, W.1.

The inaugural general meeting of the Gas Chromatography Discussion Group and an informal symposium will be held in the Chemistry Department, University College, Gower Street, London, W.C.1, on September 23. Further information can be obtained from Dr. D. Ambrose, Chemical Research Laboratory, D.S.I.R., Teddington, Middlesex.

A general discussion on "Ions of the Transition Elements", organized by the Faraday Society, will be held in Dublin during September 9–11. There will be two sessions, devoted respectively to optical and magnetic properties, and to the energetics of complexes. It is hoped to circulate advance proofs of the papers to be read. Further information can be obtained from the Assistant Secretary, Faraday Society, 6 Gray's Inn Square, London, W.C.1.

The twenty-seventh general meeting of the Society for General Microbiology will be held in the University of Liverpool on September 18 and 19. Those wishing to present papers, films or demonstrations should send the titles to Dr. B. W. Lacey not later than July 28. An informal meeting of those interested in animal viruses will be held on September 18. Further information can be obtained from Dr. B. W. Lacey, Department of Bacteriology, Westminster Medical School, London, S.W.1.

A Summer School, organized by the Universities Federation for Animal Welfare, is to be held at Culham College, Abingdon, Berkshire, during September 13–20. The programme will include lectures on various aspects of animal welfare, animal husbandry, humane technique in the laboratory, and related international problems. The fee, including full board, is £7, with a special reduced fee of £4 for students. All inquiries and applications to attend should be addressed to Miss M. P. Williams, Universities Federation for Animal Welfare, 7*a* Lamb's Conduit Passage, London, W.C.1.

SPECTROSCOPY OF SOLIDS

A CONFERENCE on the Spectroscopy of Solids, held by the Physical Society at the Royal Radar Establishment, Malvern, on May 28 and 29, brought together physicists from many parts of the world engaged in research in this field. Within the past two years, high-resolution infra-red spectroscopy has given a great deal of new information on various processes which lead to optical excitation of electrons from the valence to the conduction band in semi-conductors, and this in turn has led to a better knowledge of the band structure of silicon and germanium and also of a few of the intermetallic semi-conductors. In the opening paper of the conference, R. A. Smith discussed the various types of transition which take place in silicon and germanium, and, in particular, the part played by emission and absorption of phonons. The formation of exciton states was also discussed. These may be associated both with direct transitions in which the crystal momentum does not change, and in which no phonons are involved, and also with indirect transitions involving an appreciable change in crystal momentum and hence the emission or absorption of a phonon. Excitons associated with direct transitions give rise to a line absorption spectrum and those associated with indirect transitions to a band spectrum. Absorption due to both types of exciton formation was reported and discussed (see below).

High-resolution absorption spectra corresponding to indirect transitions in germanium, and obtained for a wide range of temperatures extending from 4° K., have previously been obtained for germanium by G. G. Macfarlane, T. P. McLean, J. E. Quarrington and V. Roberts, of the Royal Radar Establishment, showing absorption due to exciton formation. From these spectra, energies of the longitudinal and transverse acoustic phonons corresponding to the zone-edge in the $< 111 >$ directions, at which the minima in the conduction band occur, were obtained. These were found to be in good agreement with values obtained by B. N. Brockhouse and K. Iyengar from observations of neutron scattering. Similar measurements for silicon were now reported. From an analysis of these, the phonon energies for momentum values corresponding to the minima in the conduction band in the $< 100 >$ directions were obtained. Four types of phonon were observed having energies $k\theta$ with $\theta = 212°$, 670°, 1,050° and 1,420° K. These were interpreted as corresponding, respectively, to the transverse acoustic, longitudinal acoustic, longitudinal optical and transverse optical phonons. The fact that four phonons are observed and not three shows conclusively that the minima in the conduction band for silicon do not lie at the zone-edge as for germanium, since at the zone-edge the longitudinal acoustic and optical phonons have the same energy in the $< 100 >$ directions. It is estimated that for silicon the minima occur for a crystal momentum of about 0·8 times the value at the zone-edge. Accurate values for the forbidden energy gap in silicon, and for its variation with temperature, were also obtained from these measurements.

Fine structure in the recombination radiation of silicon was reported in a paper by J. R. Haynes, M. Lax and W. Flood, of the Bell Telephone Laboratories. This radiation was shown to be due to indirect transitions, and those corresponding to emission and absorption of all the four phonons discussed above were identified. Moreover, the phonon energies obtained in this way agree quite well with those obtained from the absorption spectra.

New measurements of the absorption due to the direct transition in germanium were also reported by Macfarlane, McLean, Quarrington and Roberts. These showed a strong line absorption due to the lowest exciton state. Owing to the effect of the Coulomb interaction between the free electron and hole, the form of the spectrum in the region of continuous absorption is considerably modified, and the variation with quantum energy $h\nu$ is not proportional to $(h\nu - \Delta E_0)^{\frac{1}{2}}$, as is frequently stated (ΔE_0 is the forbidden energy gap at the centre of the first Brillouin zone). The form of the continuous absorption spectrum was measured at high resolution and shown to be in very good agreement with that found theoretically on taking the Coulomb interaction of the free electron and hole into account. An accurate value for ΔE_0 is also obtained by this means.

In a theoretical paper on the phonon spectrum of germanium by F. Herman, of the Radio Corporation of America Laboratories, Princeton, forces including the effects of up to fifth nearest neighbours were taken into account. A comparison was made with the most recent observations by Brockhouse and Iyengar, using neutron scattering, of all four branches of the phonon spectrum of germanium.

The effect of strong magnetic fields on the absorption spectrum of germanium and other semi-conductors was described in papers by B. Lax and by S. Zwerdling, of the Lincoln Laboratory, Massachusetts Institute of Technology. Observation of the oscillatory magneto-absorption effect for direct transitions, due to quantization of electrons and holes into Landau levels in the magnetic field, previously reported by these authors, has been extended by use of higher spectral resolution to give the fine structure due to the degeneracy of the valence band of germanium. These observations enable the effective electron mass at the centre of the Brillouin zone to be determined. Magneto-absorption has now also been observed due to the indirect transitions involving emission and absorption of phonons. Observation of absorption in the direct transitions due to exciton formation was also reported; there was some indication of an excited state of the exciton. The variation of the position of the exciton absorption with magnetic field has also been studied.

Infra-red absorption due to impurities in semi-conductors was discussed by E. Burstein, of the Naval Research Laboratory, Washington. Recent observations have shown that the excited states of impurities in p-type silicon do not give a hydrogen-like spectrum. This effect is due to the degeneracy of the valence band at the centre of the Brillouin zone. The same author also discussed absorption spectra due to lattice vibrations in polar and homopolar crystals. New observations, with increased resolution, of the lattice absorption spectra of silicon were reported by F. A. Johnson, of the Royal Radar Establishment. It is now possible to interpret many of the absorption bands in terms of the phonon energies obtained from the indirect inter-band transitions. In most cases, two phonons are involved, but some of the weaker bands require three.

The optical properties of metals were discussed by F. Abeles, of the Institut d'Optique, Paris. Infra-red reflexion spectra have been studied with the view of obtaining information on the effective number of free electrons. Such observations for some of the noble metals and also for the alkali metals were discussed by M. H. Cohen, Cavendish Laboratory, Cambridge, who distinguished between thermal and optical effective masses and showed how the optical data may be used to determine whether the Fermi surface does or does not meet the boundaries of the first Brillouin zone.

Papers on a number of other materials were also presented, including diamond, quartz, and the compounds, InSb, CdTe and Bi_2Te_3. These were mainly concerned with observation of absorption and emission spectra. Such spectra have not yet been obtained with the same high resolution, or analysed in the same detail, as for silicon and germanium.

The conference was chosen as the occasion for the delivery of the forty-second Guthrie Lecture of the Physical Society, by Prof. W. E. Lamb, of the Clarendon Laboratory, Oxford, on "Experimental Tests of Quantum Electrodynamics".

During the conference an opportunity was available for delegates to visit the new Solid State Physics Laboratory at the Royal Radar Establishment. This was officially opened on the previous day, May 27, by the Right Hon. Aubrey Jones, Minister of Supply, together with a new laboratory for the study of guided missiles. The latter will be part of the laboratory facilities of the Guided Weapons Department under Dr. W. H. Penley. The Solid State Physics Laboratory will be included in the Physics Department under Dr. R. A. Smith. This Laboratory has been specially planned for research in the physics of solids and particular care has been taken to ensure very clean conditions. Complete air conditioning is not used throughout the Laboratory, but only in certain sections which are allocated to work in which minute quantities of certain impurities can have disastrous effects on experimental work. The new building also includes a small radiochemical laboratory and fairly extensive facilities for work at liquid-helium and liquid-hydrogen temperatures. Typical examples of the research work already beginning in the new building were demonstrated to those attending the conference. R. A. SMITH

THE DIPLOMA IN TECHNOLOGY

MANY who are concerned with the relation of science to industry combine to welcome, as a great educational reform, the institution of courses for the new Diploma in Technology. Candidature is open to science students who have obtained the General Certificate of Education (Advanced Level) or a good Ordinary National Certificate. The courses are mainly held in the top dozen or so colleges of technology, and often on a residential basis. Thus, students from Kent, Cornwall and Cumberland often study together, as at Brunel College, London, and elsewhere.

But obviously, the institution of a number of quite new degree-level courses, in different subjects, takes a good deal of working out, and raises many educational and administrative problems. In order to thrash these out further, the Brunel Staff Association held a national conference on June 20, attended by 180 delegates, being mainly senior members from the colleges concerned. Delegates were welcomed by Dr. J. Topping, principal of the College and himself a member of the National Council for Technological Awards, and by Mr. L. H. Hancock and Mr. E. E. Robinson, the conference chairman and secretary.

The opening paper, by Dr. A. J. Richmond, of the Welsh College of Advanced Technology, Cardiff, outlined the history of this great new educational venture; and the second paper, by Mr. Gordon Smith, of Brunel College, dealt with the industrial training period. While university education is all very well, it often neglects much which the young industrial scientist needs. Consequently, it was decided in 1955 to institute these new four-year courses, and on the sandwich principle. Thus, each student spends alternate periods of six months (*a*) at college and (*b*) undergoing industrial training in approved firms. Many companies now cordially welcome the scheme. Already a large proportion of the sandwich students are industry-based, that is, paid by their firms throughout the year. But the courses are open equally to students direct from a sixth form, with two advanced level and three ordinary level passes in General Certificate of Education examinations. These receive local education authority awards. More than 700 first-year students enrolled during the present session, and more than 1,000 are expected in 1958–59. The Diploma in Technology has already been recognized as the equivalent of a degree by the Burnham Committee.

Several speakers stressed the overloaded nature of many traditional science courses, where the student is expected to memorize far too many points of detail. A more selective, rather than an encyclopædic, approach is required. This comment was heard from as far apart as Mr. T. E. Hall, of Liverpool, with regard to building and civil engineering, and from Dr. E. G. Cowley, of Brighton, with regard to chemistry at both college- and school-level. It is one of the great potential virtues of the Diploma in Technology courses that syllabuses can be completely re-designed from first principles, to cope with this among other points. Mr. H. S. Barlow, of South-East Essex Technical College, however, questioned whether all colleges were seizing these exciting new educational opportunities boldly enough.

Modern methods of teaching and examining were also discussed, together with the general liberalization of approach. It was noted that those who qualify after the four years with a Diploma in Technology will be as useful to their firms as the average graduate is after another year or two of industrial training.

Further particulars about the courses are available from the Secretary, National Council for Technological Awards, 9 Cavendish Square, London, W.1.

NEW NATURE RESERVES IN ENGLAND

THE Nature Conservancy has announced the establishment of five new nature reserves in England, at Hickling Broad, Norfolk ; Bure Marshes, Norfolk ; Thetford Heath, Suffolk ; Weeting Heath, Norfolk ; and Knocking Hoe, Bedfordshire.

Hickling Broad comprises about 700 acres of shallow water surrounded by extensive reed-beds, fen, alder-wood and grass marshes characteristic of the Norfolk Broads. The history of the Broad as a bird sanctuary goes back to about 1911, when the late Lord Lucas, having bought the Whiteslea half of the Broad, approached a Hampshire friend and neighbour, Col. J. D. Mills (father of the present owner), of the Hickling half, who willingly agreed to let his part of it to form the sanctuary. Jim Vincent was appointed keeper. After the death of Lord Lucas, the ownership of one half and the lease of the other passed to the late Lord Desborough, who maintained the sanctuary at considerable personal expense with Jim Vincent's invaluable help.

The newly created National Nature Reserve, which lies 10 miles north-west of Great Yarmouth and covers an area of about 1,204 acres, has been established under Nature Reserve agreements with the owners, the Norfolk Naturalists' Trust and Major J. M. Mills.

The aquatic plant *Naias marina*, found in Britain only in certain Broads, is abundant at Hickling, together with many other rare plants, which are found in the marsh communities. The rich flora also supports some notable insects, of which the most outstanding is the swallowtail butterfly. The bittern, which re-established itself as a British breeding species on the nearby Sutton Broad in 1911, has bred at Hickling again since 1912, and the marsh harrier, which was also virtually extinct as a breeding species, returned rather later. To-day, harriers, bearded tits and bitterns are flourishing, together with several species of ducks, waders and other interesting birds.

The coypu, a large South American rodent which is now widespread in the Broads area, was first recorded at Hickling in 1950. It eats large quantities of vegetation and has in places eliminated much of the lesser reedmace. The increase of open water by eating out and breaking up encroaching plant life seems, on balance, so far to have been beneficial.

Those accustomed to visit the area will find no change as regards access, and the declaration as a reserve will not in any way affect the use of the Broad for sailing and fishing. Applications to visit the adjoining sanctuary area and for permits to collect specimens of plants and animals should be sent to the Secretary, Norfolk Naturalists' Trust, The Assembly House, Theatre Street, Norwich. Inquiries regarding proposed researches should be addressed to the Regional Officer for East Anglia, The Nature Conservancy, Government Offices, Bishopgate, Norwich.

The problem of the evolution and future of the Norfolk Broads is of considerable scientific and economic interest. Recent research has shown that many Broads were man-made in the Middle Ages and has partly explained why so many have become unnavigable lately. The Nature Conservancy has been asked to make a long-term scientific investigation of this problem, but as, unfortunately, no money could be found for it a start has not yet been possible. In addition to money and specialist staff, experimental areas are essential on which the scientists can work. These have now been provided through the generous co-operation of the Norfolk Naturalists' Trust and Col. Harry Cator and Mr. John Cator, of Woodbastwick, who have entered into Nature Reserve agreements on 734 acres of marshes and small broads (stretching some 2 miles from Ranworth to Decoy Broad, on the right bank of the Bure), which now comprise the Bure Marshes Nature Reserve.

Ranworth and Cockshoot Broads were given in 1949 by Col. Cator to the Norfolk Naturalists' Trust, who, with the support of the Conservancy, will continue to manage these Broads and marshes. Management of the privately owned Woodbastwick area also remains in the hands of its owners, and there will be no change as regards use or access.

The Breckland of south-west Norfolk and north-west Suffolk is an area of sandy heaths of the greatest importance for research on plant and animal populations in arid conditions resulting from its semi-continental climate and conjunction of sandy and chalk soils. Agricultural reclamation, afforestation, defence needs and other development have made great inroads into the unspoilt Breckland during the past thirty years. Thetford Heath, Suffolk, which lies 2½ miles south-west of Thetford and covers 225 acres, has been protected by the Norfolk Naturalists' Trust since 1949, and this reserve is now being declared under an agreement with the Trust.

Breckland birds in special need of conservation are well represented, and the breeding species include stone curlew, woodlark, wheatear and ringed plover. Most of the typical Breckland plants are to be found on Thetford Heath, which has, however, a stony broken ground surface with an incomplete covering of vegetation over a considerable area. During the 1930's parallel stripes of heather were observed, but it was not until recent years that this was connected with collections of flints in long parallel lines—the stone stripes revealed after the removal of a small area of surface soil during the Second World War.

Applications to visit and for authority to collect specimens of animals and plants should be made to the Regional Officer for East Anglia, The Nature Conservancy, Bishopgate, Norwich.

Weeting Heath, Norfolk, which has a wide range of Breckland heath vegetation types and consequently a flora and fauna of considerable interest, was purchased and presented to the Norfolk Naturalists' Trust in 1941, and a further area was added in 1944. Weeting Heath lies west of Brandon and covers 338 acres.

Typical Breckland birds, such as stone curlews, woodlarks, wheatears and a few pairs of ringed plovers (which rarely breed so far inland), are to be found. In the mid-section there is a wide area of bracken, and the reserve is separated from afforested land on the west by a well-defined stretch of ancient earthworks known as the Devil's Dyke. The absence of the rabbit from Weeting during the past two years has enabled uncommon plants to flower which had not been recorded there for many years. The northern section of Weeting Heath consists largely of chalky grassland forming a thick turf with pine trees scattered in groups. The more barren parts of the heath have yielded a very rare spider (*Oxyptila scabricula*), and another spider (*Philodromus collinus*) occurs only at two other places in Britain.

Applications for permits, which will be necessary for those who wish to visit the reserve, to undertake research and to collect specimens of animals or plants, should be addressed to the Regional Officer for East Anglia, The Nature Conservancy, Bishopgate, Norwich.

Knocking Hoe in Bedfordshire is a small relic of a particular type of close-grazed chalk downland turf, which is rapidly disappearing under the present system of land use in Britain. The turf is thought to be of very ancient origin, and has probably remained undisturbed by cultivation at least throughout historic times. There is a rich flora of low-growing chalk downland species. The reserve has been established under a Nature Reserve agreement with the owner, Mr. L. T. Franklin. It will continue to be used for sheep grazing, as this is considered to be the best way to preserve the present composition of the sward. Access to the reserve will be by permit only, of which only a very limited number will be issued. Applications can be made to the Regional Officer for the South-East, The Nature Conservancy, 19 Belgrave Square, London, S.W.1.

POPULATION STUDIES OF THE COMMON EARWIG

DURING the summer of 1956, there was a plague of the common earwig (*Forficula auricularia* Linn.) in the garden of 28 Yarborough Road, Lincoln. Traps were erected to catch the earwigs and large numbers were caught. P. F. Baker (*Trans. Lincolnshire Naturalists Union*, 14, No. 2; December 1957) made a study of the relative numbers of males and females in the population and of the percentage of the population consisting of the variety with large elliptical forceps, known as form *forcipata* Steph. Later, it was decided to investigate the distance moved by different individuals in the population; this was done by a marking experiment.

The final total of 337 males and 332 females showed that during August and September 1956, in the earwig colony studied, males and females were present in almost equal numbers.

The males were found to be the most variable: the commonest varieties being those in which one-half of the calipers differed markedly in curvature from the other. This was found in both typical and form *forcipata* males. Two specimens were caught which from their external appearance seemed to be gynandromorphs.

Previous work on population statistics had led to the belief that earwigs were migrating from one part of the garden to another and it was decided to assess the movements of separate individuals in the population. To investigate movement an evenly spaced network of traps was set up over the area so that each trap was about one yard from its immediate neighbours. Separate pots were labelled and all insects caught in any particular pot were marked on the elytra with oil paints of a colour characteristic of the pot.

To mark the insects during a period of relative quiescence—from general observations the earwig seemed to be active at night and inactive, or nearly so, during the daylight hours—an actograph was used. This relied on a displacement of equilibrium as the insect moves in a cage; a mark is registered on a drum. In this way the earwig was shown to be entirely nocturnal, commencing activity at dusk and continuing to dawn. For this reason removal of the insects from the traps was carried out in the daytime; these earwigs were then marked with oil paint and released at the base of the trap in which they were caught. The marking, to be recognizable, usually lasted for one retrapping only; other earwigs ate the oil paint off their fellows.

Recaptures of marked individuals made up 12 per cent of the whole.

The results showed small daily migrationary trends. In this case conditions were ideal and food was not scarce. It is known, however, that the common earwig will, under special environmental conditions or when food is scarce, migrate in thousands in search of new grounds.

DIRECTING YOUNG SALMON

RESEARCH on the methods of guiding young Pacific salmon while migrating downstream have recently been described by J. R. Brett and D. F. Alderdice (Fisheries Research Board of Canada. Bulletin No. 117: Research on Guiding Young Salmon at Two British Columbia Field Stations. Pp. viii+75. Ottawa: Queen's Printer, 1958. 75 cents).

The first experiments, in 1953, were performed in a large divided trough using captive sockeye yearlings. These tests were intended to survey broadly the possibilities of using various techniques, including light, sound, air bubbles, curtains of hanging chain, odours, dye releases and differences in water velocity as means of guiding young fish. Significant deflexion resulted from the use of a relatively large area of illumination at night, a band of rising air bubbles or bursts of dark dye during the day, and strands of chain hung vertically during both day and night.

Further trough experiments, in 1954, on the use of hanging chain demonstrated that the maximum distance between strands which produced a deflexion of 75 per cent or more fish through an angle of 45° was 4 in. Apart from its light-reflecting quality, the type of chain was found to be unimportant. The sensory stimulus causing the avoiding reaction was found to be primarily visual. Slow oscillation of the chain increased the deflexion of sockeye. Coho yearlings were not significantly deflected.

In conjunction with the trough experiments, a limited number of field tests using a 56-ft. oscillating chain deflector (144 oscillations a minute) in the

Lakelse River, British Columbia, proved that the technique had promise for guiding a natural run of young sockeye. At right angles to the direction of water flow a maximum of 79 per cent deflexion was achieved. However, the barrier was subject to considerable penetration if conditions were not ideal; coho were still not effectively deflected.

A number of modifications was introduced in the 1955 deflector. The chain was replaced by cables which were suspended from a continuous moving belt. The belt travelled across-stream, reversing at the entrance to the trap. Various intervals and rates of travel (to a maximum of 12 in./sec.) were tested. The combinations which proved most effective included an interval between strands of not more than 6 in., and rates of travel from 8 to 12 in./sec. In these circumstances an average of 92 per cent of sockeye and 59 per cent of coho were deflected.

In addition to changes in the deflector, a new opening or by-pass to the inclined-screen trap was built. The particular features of the by-pass were a reduction of visual cues in the entrance by using smooth, painted surfaces, a gradual acceleration of the incoming water to a velocity equal to or just exceeding the maximum swimming speed of the migrants, and the presence of cross-reflecting mirrors. Although the first model had limitations, it improved the trapping of deflected fish and permitted a good numerical assessment of the deflector.

The final tests were conducted in Hoolnose Creek during the spring of 1956. Pink, chum and coho fry, as well as sockeye and coho yearlings, migrate down this small stream. The same deflector was used, with additional features of smaller, weighted cables, a minimum interval of 2 in. between strands, low direct-current charging of the moving cables, and a 3-ft. wide sheet of metal on the stream bed, painted white to reflect light incident on the surface. The reduction in spacing was introduced to scale down the interval dimensions to a more appropriate size for fry. Also, by adding an electric charge, a combination of stimuli was presented which was thought would be more effective.

No success was obtained in guiding any of the fry. However, both coho and sockeye fingerlings were deflected at 95 per cent level and higher.

The investigations showed that new methods must be sought for the guiding of salmon fry. For yearlings, a full-scale test is desirable under conditions which approximate to reservoir characteristics of large dams.

A NEW APPROACH TO THE CHEMOTHERAPY OF CANCER

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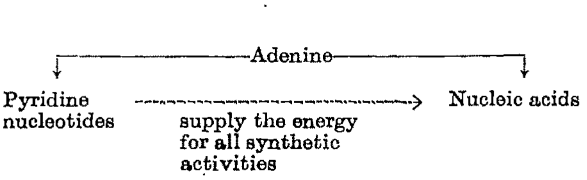
THE use of antimetabolites as a means of controlling cancer was first investigated by Sidney Farber[1] in 1948, using folic acid antagonists. Since then a number of compounds having antagonistic properties against such essential metabolites as purines[2], pyrimidines[3], vitamins[4] and glucose[5] have been tested. The main drawback of the antimetabolites tested so far has been that they interfered with the normal processes also, and as such exhibited toxic effects. Further, some of the tumours develop resistance to the drugs. The former difficulty might be overcome by using antimetabolites against a specific substance or substances having an important function in tumours only; but in spite of the large amount of work, such a qualitative difference between a tumour and normal tissue has not so far been discovered. There are, however, quantitative differences which might be exploited with advantage in the chemotherapy of cancer.

One of the striking differences between normal and malignant tissues is the active cell proliferation accompanied by high rate of synthesis of nucleic acid in neoplastic tissues. This high rate, however, is not a characteristic solely of neoplastic growth. Normal embryonic tissues are also known to exhibit active nucleic acid synthesis without any evidence of neoplastic transformations. Hence embryonic and tumour tissues are similar in so far as active cell proliferation and nucleic acid synthesis are concerned; but whereas embryonic growth comes to a stop after a while, the tumour continues to grow apparently without any control whatsoever. In the present communication an attempt is made to explain these differences in the light of existing knowledge, and to suggest ways and means of exploiting these differences to control cancer growth.

Regulation of Normal Growth by Biological Feed-Back Mechanism

To maintain the rapid rate of synthesis of nucleic acid, two things are essential: (i) a continuous flow of precursors and (ii) an unrestricted supply of energy. In the biological system, the energy is usually generated in the Krebs tricarboxylic acid cycle through the stepwise degradation of metabolites into carbon dioxide and water. Pyridine nucleotides have an important role in this connexion in the hydrogen transport system, and thus indirectly participate in the energy production via the tricarboxylic acid cycle. One of the precursors of pyridine nucleotides is adenine, which is also a precursor of nucleic acids. Since the same substance (adenine) is required for the synthesis of nucleic acid and also of pyridine nucleotide, a sort of chemical competition is set up between the two for appropriation of adenine.



In an actively growing tissue, unless larger amounts of adenine are made available from the metabolic pool, it (adenine) is likely to be used for the synthesis of nucleic acid and very little will be left for the synthesis of pyridine nucleotides. This seems to be corroborated by published work[6] on the levels of pyridine nucleotides in various tissues (see Table 1).

Table 1. TOTAL DIPHOSPHOPYRIDINE NUCLEOTIDES + REDUCED DIPHOSPHOPYRIDINE NUCLEOTIDE IN THE LIVER OF ADULT, EMBRYONIC, NEW-BORN AND HEPATECTOMIZED RATS
(Compiled after Jedeikin, Thomas and Weinhouse, ref. 6)

	Total DPN + DPNH	Percentage lowering in total pyridine nucleotides
Liver from adult rats	770 (731–819)	
Liver from 19–20 day fœtus	262	66
Liver of new born 1–3 hr. after birth	441	43
Liver of new born 1 day after birth	336	56
Liver of new born 7 days after birth	722	Values within normal range
Maternal liver of 19–20 days pregnant mother	550	28
Liver of mother 1 day post-partum	846	Values within normal range
Regenerated liver 3 days after hepatectomy	592	23
Hepatoma	250	78

Table 2. PYRIDINE NUCLEOTIDE LEVELS IN HOST TISSUES (μGM./GM. WET TISSUES) OF TUMOUR-BEARING ANIMALS: INFLUENCE OF NICOTINAMIDE ADMINISTRATION ON *in vivo* STIMULATION OF SYNTHESIS OF PYRIDINE NUCLEOTIDE
(Compiled after Narurkar, Kumta and Sahasrabudhe, ref. 7)

	Livers		Spleen		
	Control animals	Tumour-bearing animals	Control animals	Tumour-bearing animals	Tumour (fibro-sarcoma)
Initial	671	561	456	337	119
Levels of pyridine nucleotide after administration of 500 mgm./kgm. body wt. nicotinamide	3,063	1,334	2,900	892	611
Net synthesis of pyridine nucleotide in 12 hr.	2,393	773	2,444	535	492

It will be seen from Table 1 that active proliferation is invariably accompanied by lowering of the pyridine nucleotide levels. The figures for livers of mothers 19–20 days pregnant suggest that not only the adenine present in the fœtus is channelized for nucleic acid synthesis, but even that present in the metabolic pool of the mother is also drained, resulting in the depletion of pyridine nucleotide levels in the maternal livers of pregnant animals.

Sahasrabudhe and co-workers[7] have recently demonstrated that the pyridine nucleotide levels in the host tissues of tumour-bearing animals are considerably lower. Nicotinamide ribotide and adenine ribotide combine by a pyrophosphate bond to form a pyridine nucleotide molecule: nicotinamide–ribose–P–P–ribose–adenine. Kaplan[8] has shown that when nicotinamide is administered, pyridine nucleotide synthesis can be artificially boosted. The levels of pyridine nucleotide synthesized, however, will be determined by the availability of adenine from the metabolic pool for the synthesis of pyridine nucleotide. Sahasrabudhe and co-workers[7] attempted to stimulate the *in vivo* synthesis of pyridine nucleotide by injecting 500 mgm./kgm. body-weight of nicotinamide. The livers and spleens of normal non-tumour-bearing animals showed a net synthesis of 2,393 and 2,444 μgm. of pyridine nucleotide. The net synthesis in the liver, spleen and tumour of tumour-bearing animals, however, was only 773, 553 and 492 μgm.; that is, less than a third of that in tissues of normal animals (Table 2). This clearly suggests the unavailability of adenine for the synthesis of pyridine nucleotide in tumour-bearing animals.

But this appropriation of adenine for nucleic acid synthesis and the depletion of pyridine nucleotide levels cannot go on indefinitely, because in absence of adequate levels of pyridine nucleotide, hydrogen transport and energy production cannot go on efficiently. Since nucleic acid synthesis requires energy, the appropriation of adenine will itself act as a self-regulatory feed-back mechanism by limiting the pyridine nucleotide levels. This, it is suggested, is the mechanism by which normal hyperplasia comes to a stop after a particular level of proliferation has been achieved. The fact that tumours continue to grow indefinitely, apparently without the self-regulating feed-back mechanism just described, suggests that the tumours find alternative ways of producing their own energy requirements, independent of pyridine nucleotide levels and the tricarboxylic acid cycle.

Run-Away Growth in Tumours: Tumour Autonomy in Energy Production

Until recently, the Embden–Meyerhof pathway was regarded as the sole prototype of glycolysis whereby glucose was metabolized through the formation of glucose-6-phosphate, fructose-6-phosphate, fructose-1-6-diphosphate and triose phosphate, etc., as shown in Fig. 1. It is only recently that growing evidence has been forthcoming through the researches of Warburg, Lipman and Dickens to suggest an alternative pathway of glycolysis known as the hexose–monophosphate shunt or oxidative pathway[9].

In the absence of adequate levels of pyridine nucleotide, as in actively growing tumour tissues, the operation of the tricarboxylic acid cycle and the production of adenosine triphosphate are impaired, which perhaps result in accumulation of lactic acid. In the hexose–monophosphate pathway, no adenosine triphosphate is required; instead, an obligatory oxidation occurs early in the reaction sequence. It has been shown that sedoheptulose-7-phosphate and erythrose-4-phosphate can either be converted to triose phosphate and thus meet the Embden–Meyerhof pathway, or these may alternatively be converted to fructose-6-phosphate and re-enter the hexose–monophosphate cyclic processes[9]. Repeated opera-

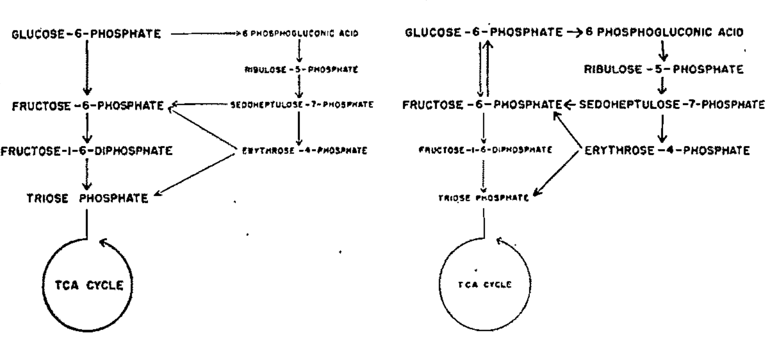


Fig. 1. Relative preponderance of Embden–Meyerhof and hexose-monophosphate pathways of glycolysis in normal and neoplastic tissues. Bold lettering and thick lines indicate the preponderance

tions of the hexose–monophosphate oxidative cycles yield carbon dioxide as the sole and final product, with the release of all the energy contained in the glucose molecule. How this energy is utilized is, however, not definitely known. It is perhaps a happy coincidence that the major portion of the ribose moiety, which is so essential for nucleic acid synthesis, is derived from the hexose–monophosphate pathway. It is felt that this is an example of efficient biological adaptation to get over the block in energy production and to get the most benefit with the least effort. Whatever be the correct explanation of this phenomenon, the cause and effect relationship appears to be very striking and calls for closer scrutiny. Whether any sustained and rapid synthesis of nucleic acid automatically accelerates the hexose–monophosphate pathway as an adaptive mechanism, or whether this is a characteristic of neoplastic transformations only, is at present under investigation and will be reported elsewhere.

Radioactive isotope technique has played a vital part in evaluating the relative rates at which the alternative pathways of glycolysis predominate in a given system. For this purpose samples of glucose labelled at the first or the sixth carbon atoms with carbon-14 have been used, and by determining the radioactivity in the carbon dioxide formed, one can evaluate the extent to which the two alternative glycolytic pathways are operative[10]. Using this technique, Van Vals, Bosch and Emmelot[11] have demonstrated the preponderance of the hexose–monophosphate oxidative pathway in a variety of tumours and their results are briefly summarized in Table 3.

Table 3. INCORPORATION OF RADIOACTIVITY IN CARBON DIOXIDE USING GLUCOSE-1-^{14}C AND GLUCOSE-6-^{14}C AS SUBSTRATES
(After Van Vals, Bosch and Emmelot, ref. 11)

	Ratio of *R*6/*R*1*	
	Without malonate	With malonate
Heart	1·05	0·42
Kidney	1·01	0·52
Brain	1·08	0·46
Spontaneous mammary carcinoma (*Dba*)	0·60	0·18
*T*5358 : interstitial cell carcinoma testis	0·51	0·13
*UV*256 sarcoma	0·58	0·02
*T*26567 sarcomatoid ovarian tumour	0·72	0·25

$$^{*}\frac{R6}{R1} = \frac{\text{Radioactive CO}_2\text{ liberated using glucose-6-}^{14}\text{C}}{\text{Radioactive CO}_2\text{ liberated using glucose-1-}^{14}\text{C}} = \frac{\text{(EM and TCA)}}{\text{(EM and TCA)} + \text{(HMP)}}$$

There is, however, one point which needs explanation. The two dehydrogenases in the early reaction sequence of the hexose–monophosphate pathway are dependent on the level of triphosphopyridine nucleotide. The question that naturally arises is how do these dehydrogenases function at higher levels when the levels of total pyridine nucleotide and triphosphopyridine nucleotide in particular are depleted. Glock and McLean[12] have examined this point closely and have found high values of dehydrogenase activity with low levels of triphosphopyridine nucleotide. Either it means that the tumour dehydrogenases are not dependent on triphosphopyridine nucleotide or that some other substance such as a specific dinucleotide acts as a hydrogen carrier in place of it.

Summarizing, therefore, it is suggested that the high rate of synthesis of nucleic acids in malignant transformations results in depletion of the levels of pyridine nucleotides and acceleration of the hexose–monophosphate pathway to obtain the energy required for proliferation. How low the level of pyridine nucleotides becomes will depend on how fast the synthesis of nucleic acid is going on. This concept of chemical competitions as the causative factor determining the levels of pyridine nucleotides, if true, might help in reconciling the divergent views held by Warburg[13] and Weinhouse[14] regarding the role of respiration in tumour tissue.

New Approach to Chemotherapy

It would appear from the foregoing discussion that the tumour derives its energy via the hexose–monophosphate pathway. It may be because of the independence of this pathway from normal regulatory feed-back mechanism that the tumour enjoys autonomy with regard to production of energy for its proliferation. Further, since the hexose–monophosphate pathway is not operative to a major extent in other normal tissues, any interference with that pathway might result in preferentially arresting the tumour growth only.

The possibilities and usefulness of preparing antimetabolites against glucose-6-phosphate, 6-phosphogluconic acid, ribulose-5-phosphate, etc., have therefore been considered. Since glucose-6-phosphate takes part in the Embden–Meyerhof as well as in the hexose–monophosphate pathway, use of its antimetabolites would exhibit toxic effects due to blockage of the Embden–Meyerhof pathway in normal tissues. Similarly, ribose is a constituent of a number of essential cofactors such as diphosphopyridine nucleotide, co-enzyme A, etc., which are necessary for normal body processes. Any substance, therefore, which interferes with ribose utilization would interfere with normal processes also and might prove toxic. Analogues of 6-phosphogluconic acid, however, appear to be free from any such objections. Work is at present in progress in this laboratory along these lines, and the preliminary results so far obtained with experimental chemotherapy of cancer with some of the compounds specially synthesized for the purpose are very encouraging. Details of this work will be published elsewhere.

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DISTRIBUTION OF PELAGIC POLYCHÆTES IN THE SOUTH ATLANTIC OCEAN

By NORMAN TEBBLE

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IT has been established that the major hydrological boundaries in the South Atlantic Ocean restrict the distribution of many species of zooplankton[1]. Examination of pelagic polychætes collected by the "Discovery" Committee, between the ice edge (in 70° S.) and the equator, demonstrates for the first time that many of these have a significant distribution in relation to the sub-tropical and antarctic convergences. Minor hydrological boundaries affect the dispersal of particular populations and a correlation has been found to exist between the distribution of species and the movements of water masses.

Three pelagic polychætes do not occur north of the antarctic convergence and are endemic to the antarctic zone; they are *Rhynchonerella bongraini*, *Vanadis antarctica* and *Tomopteris carpenteri*. In the Atlantic sector *R. bongraini* has been found only in the top 500 m. of water in the antarctic zone within Weddell Sea water, the east wind drift, and in the upper layers of the warm deep water. *V. antarctica* probably occurs in all explored water masses in the antarctic zone; it is similar morphologically to *Vanadis longissima*, from farther north, and they may represent geographical races of one species. *Tomopteris carpenteri* was found, as adult, in all explored water masses of the antarctic zone; the smallest specimens of this species were, however, collected around South Georgia only, which suggests it may be a breeding area.

There seem to be no endemic sub-antarctic pelagic polychætes, *Vanadis longissima* being the only species (or geographical race of a species) with its southerly limit of distribution at the antarctic convergence; apart from occurring in the sub-antarctic zone it was collected only in the sub-tropical and tropical zones.

The following species have been found in the tropical and sub-tropical zones only; they appear to be limited in their southerly distribution by the sub-tropical convergence: *Tomopteris ligulata**, *T. krampi*, *T. elegans**, *T. apsteini**, *T. nisseni*, *Vanadis formosa**, *V. crystallina**, *Rhynchonerella angelini*, *Krohnia lepidota**, *Alciopa reynaudi**, *Naiades cantraini**, *Travisiopsis lobifera**, *T. lanceolata*, *Lopadorhynchus brevis**, *L. uncinatus**, and *L. krohni**.

It is noteworthy that twelve of these species (marked with an asterisk) are not known to occur in the North Atlantic Ocean to the north of the secondary polar front (as defined by Böhnecke[2]), which is a similar hydrological boundary to the sub-tropical convergence in the South Atlantic. These species appear to circulate in the Atlantic Ocean entirely between these boundaries.

The remaining species, *Tomopteris nisseni*, *T. krampi*, *Rhynchonerella angelini* and *Travisiopsis lanceolata*, range northward beyond the secondary polar front in the North Atlantic Ocean—in brief, this front is no barrier to them. No endemic pelagic polychætes are known from arctic waters, which implies that there is a constant influx of more southerly populations maintaining the homogeneity of the species over a wide area and preventing the evolution of endemic species. It is possible, therefore, that the endemic antarctic *Tomopteris carpenteri* may be represented in the arctic fauna by *T. nisseni* and *T. krampi*. Similarly, the endemic antarctic *Rhynchonerella bongraini* corresponds to *R. angelini*. Likewise, although the genus *Travisiopsis* is not represented by an endemic species in the antarctic zone, the species *T. coniceps* occurs only in southern waters and its corresponding species in arctic waters is *T. lanceolata*.

The following species were collected in all hydrological zones in the South Atlantic Ocean: *Tomopteris planktonis*, *T. septentrionalis*, *Typhloscolex mülleri*, *Travisiopsis levinseni* and *Pelagobia longicirrata*. Of these, *Tomopteris planktonis*, *T. septentrionalis* and *Travisiopsis levinseni* were collected in all explored water masses but never in regular abundance. *Typhloscolex mülleri* was collected in the antarctic zone in the warm deep water thoughout the year, migrating to depth in winter. A few records from the surface layers in summer suggest that at this season this species may also penetrate into Weddell Sea water. North of the antarctic convergence *T. mülleri* inhabits antarctic intermediate water, South Atlantic central water, and possibly also tropical surface water. *Pelagobia longicirrata* is the most abundant of all pelagic polychætes, and south of latitude 45° S. undergoes a migration to depth in winter. This species has been found in its greatest numbers in summer in the top 100 m. of water about the Greenwich meridian in the antarctic and sub-antarctic zones between the ice edge and 45° S. North of this latitude, to the sub-tropical convergence, it has not been found between 100 m. and the surface in samples so far examined. Böhnecke[2] has noted the presence of a boundary in this region which separates well-mixed water in the southern half of the sub-antarctic zone from more stably stratified water in the northern half; this boundary may segregate a southern population of *P. longicirrata* which inhabits these surface layers in summer (whether for feeding or for breeding purposes is not known). Elsewhere in the South Atlantic Ocean *P. longicirrata* has been collected in all explored water masses.

The distribution of species occurring at depth and limited in their range by surface hydrological boundaries may be explained by migration between water masses moving in opposite directions. Throughout the sub-tropical and tropical zones, species which do not occur south of the sub-tropical convergence could maintain their environment by migrating between southerly flowing South Atlantic central water, northerly flowing antarctic intermediate water and/or southerly flowing warm deep water. Surface currents throughout these zones set up an anti-clockwise circulation which would also restrict the southerly movement of the species.

It is probable that most cosmopolitan pelagic polychætes enter the antarctic and sub-antarctic zones in the southerly flowing warm deep water. By migrating upwards in the antarctic zone to antarctic surface water, and moving with this layer to its conversion into northerly flowing antarctic intermediate water, circulation throughout the South Atlantic would be maintained. Within the antarctic zone a closed circulation, between antarctic surface water and warm deep water, is the simplest explanation of zonal movement, but endemic antarctic species, and antarctic populations of cosmopolitan species, are undoubtedly affected by much more complex circumpolar influences.

A full account of this study will be published elsewhere.

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RELATIONSHIP BETWEEN PHYTOALEXIN OUTPUT AND THE NUMBER OF INFECTIONS INVOLVED

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As previously reported[1], the germ tubes of *Phytophthora infestans* readily penetrate the epidermis of the seed cavities of *Phaseolus vulgaris*. The result of such penetrations is seen as necrotic lesions involving usually only one or two host cells, but the pathogen simultaneously ceases to grow and spread.

It was later shown[2] that the pathogen is checked by the antibiotic factor, phytoalexin, which results after infection from an interaction between the host tissue and the pathogen. In an attempt to study the relationship between the number of germ tubes penetrating into the host cells and the output of phytoalexin, experiments using known concentrations of zoospore suspensions were carried out along the following lines.

The pod cavities were inoculated with known volumes of zoospore suspensions varying in concentration from 8×10^{2} to 10^{4} zoospores per cm.^{3}. After incubation for 24 hr. at 20° C., the droplets were collected and the solutions thus obtained were tested in serial dilution by bio-assay with *Sclerotinia fructicola*[2], for their antibiotic activity. The latter was assessed by determining that dilution at which the length of the germ tubes was fifty per cent of that of the control. The reciprocal of this dilution was taken as the measure of activity in the undiluted solution or of the number of phytoalexin units per mm.^{3} of that solution. By definition, unit activity results from 1 phytoalexin unit per mm.^{3}, and this concentration will reduce the growth of germ tubes to one-half in the standard assay technique.

The number of cells directly affected by the pathogen was determined by removing the inoculated epidermal layers from the treated cavities after the inoculation drops had been collected, and by placing them in a 10 p.p.m. rhodamine *B* solution. After 3 hr. these layers were examined microscopically. The invaded and one or more adjoining cells showed staining. The figures in Table 1 refer to the number of penetrations per mm.^{2} of inoculated area.

The results tabulated are the averages for four experiments. It can be seen that there is no correlation between the number of infections (or penetrations) and phytoalexin output per mm.^{2} of inoculated host tissue. Only when the suspension was so diluted as to reduce the number of zoospores per mm.^{2} to less than 1 was an effective decrease in phytoalexin activity recorded.

It is pertinent to calculate the theoretical output of phytoalexin per mm.^{3} of inoculated epidermal tissue, on the assumption that ultimately there is the same concentration of phytoalexin in the bulk diffusate as in the affected cells. The calculation is also based on the assumption that the whole of the cell volume participates in the production of phytoalexin, and that no phytoalexin is inactivated by zoospores in the bulk diffusate. Any appropriate corrections would, however, increase the theoretical concentration of phytoalexin. The result of such a calculation is shown in the second row of Table 1.

The third row in Table 1 gives the calculated output of phytoalexin per mm.^{3} of affected cells. These figures are extremely high when one considers that 5–6 units of phytoalexin per mm.^{3} of water will completely inhibit hyphal growth *in vitro*. Thus when there are 56 penetrations per mm.^{2} of epidermal tissue the output of phytoalexin is more than 350 times that necessary to inhibit completely hyphal

Table 1. NUMBER OF PENETRATIONS PER MM.^{2} OF INOCULATED AREA AND OUTPUT OF PHYTOALEXIN

	Number of infections/mm.^{2} inoculated area								
	56	27	18	12	7	3	3	2	0·5
(1) Phytoalexin concentration in activity units in bulk diffusate	5·0	4·3	6·7	5·0	5·0	5·0	2·4	3·4	< 0·5
(2) Phytoalexin act. units produced/mm.^{3} epidermal tissue*	237	202	315	237	237	237	113	160	< 23·5
(3) Phytoalexin act. units produced/mm.^{3} affected tissue*	$2·16 \times 10^{3}$	$3·85 \times 10^{3}$	$9·01 \times 10^{3}$	$1·01 \times 10^{4}$	$1·73 \times 10^{4}$	$4·04 \times 10^{4}$	$1·94 \times 10^{4}$	$4·12 \times 10^{4}$	$< 2·42 \times 10^{4}$

* Calculated from figures of row 1, in using the following data and formulæ:

Mean vol. liquid recovered from a single inoculated area = 9·2 mm.^{3}
Mean single epidermal area covered by the inoculum = 8·45 mm.^{2}
Mean depth of the epidermis = 23μ
Mean vol. of an individual epidermal cell = 28,100μ^{3}
Mean number of cells affected per point of penetration = 1·6

$$\text{Phytoalexin produced/mm.}^{3}\ \text{epidermal tissue inoculated} = \frac{\text{Phytoalexin conc.} \times 9·2}{8·45 \times 0·023}$$

$$\text{Phytoalexin produced/mm.}^{3}\ \text{tissue infected} = \frac{\text{Phytoalexin conc.} \times 9·2 \times 10^{9}}{\text{Infections/mm.}^{2} \times 8·45 \times 28{,}100 \times 1·6},$$

growth at the site of infection; when there are 2 penetrations per mm.^{2} the output of phytoalexin is some 7,000 times more than that necessary.

The conclusions that (1) the output of phytoalexin is excessively high per unit volume of affected cells, and (2) the output of phytoalexin is essentially constant per unit area of inoculated area suggest that not only the invaded cells but also the rest of the tissue adjacent to the inoculated face participates in the formation and liberation of phytoalexin. If so, it must be assumed that a factor diffuses into the inoculation drop which induces the non-infected cells to produce the inhibitory substance in their turn. In view of the fact that measurements of conductance in tissues interacting with the pathogen in a suprasensitive fashion showed evidence of effect in advance of the pathogen[3], the above suggestion need not be considered too speculative. Also, the recent findings of Millerd and Scott[4], who separated a chemical factor from barley leaves infected with *Erysiphe graminis* which increases the respiratory rate in uninfected leaves, fit in with this hypothesis.

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STEREOCHEMISTRY OF COMPLEX HALIDES OF THE TRANSITION METALS

By Dr. NAIDA S. GILL, Prof. RONALD S. NYHOLM, F.R.S., and PETER PAULING

THE ligand (crystal) field theory, originally developed by Bethe[1] and Van Vleck[2], has been used extensively since 1951 for the interpretation of the spectra of transition metal complexes[3]. It had been employed earlier to explain the magnetic properties of compounds of the transition[4] and rare earth metals[5], and, more recently, those of the actinide metals[6]. It has also proved very valuable in providing an increased understanding of the stereochemistry of transition metal complexes[7,8].

The ligand field theory considers the effect of the electrostatic field due to the ligands on the energy of the non-bonding d-shell of the central metal atom and assumes that the arrangement of the ligands about the metal atom is determined primarily by this non-bonding d-shell. The successes of the ligand field theory suggest that in many molecules and complex ions the dominating energy terms are indeed those related to electrostatic effects on the inner non-bonding d-electrons. We wish to direct attention in this article to cases in which this is not true, and in doing so to delineate more precisely the value of ligand field and other theories in the prediction and interpretation of the stereochemistry of transition metal complexes. While recognizing the validity of the energy effects calculated by ligand field theory, we believe that other factors such as the stabilizing energy of the directed σ-bond, the principle of electroneutrality of the metal ion[9], the polarizability of the ligand, the possibility of π-bonding between metal and ligand and the steric effects which result from interaction between ligands, are potentially important as structure determinants. We suggest that sometimes these may overcome ligand field effects and give rise to co-ordination shapes different from those expected from simple ligand field theory. First, we regard the principle of electroneutrality as of major significance in deciding the co-ordination number of the metal ion, for a knowledge of this must precede discussion of stereochemistry. In general, the preferred co-ordination number of a metal ion increases with its valency, and Pauling[9] has suggested that, as a rough rule, the co-ordination number is twice the valency. It is well known, however, that two or more co-ordination numbers may occur for the same metal ion; for example, $[FeF_6]^{3-}$ and $[FeCl_4]^-$. We consider that this arises not so much from steric effects as from differences in the polarizability of the various ligands and consequent transfer of charge to the metal ion through the σ-bond. For example, Fe^{3+} takes up ligands until its effective charge is reduced to nearly zero; it will require a greater number of F^--ligands to achieve this than Cl^--ligands, because there is greater electron transfer from each Cl^- to Fe^{3+} than from each F^-. Another example of this is the comparison of $[Co(H_2O)_6]^{2+}$ with $[CoCl_4]^{2-}$; the co-ordination number decreases as we pass from the less easily polarized H_2O to the more readily polarized Cl^- ligand.

Before discussing the shapes of complexes of metals the atoms of which have a non-spherical electronic shell, it is helpful to summarize the shapes expected for ions which have perfect spherical symmetry. As discussed elsewhere[8], the stereochemistry of complexes of non-transition metals can be generalized in terms of repulsions between *bonds* (whether single, double or triple) and lone pairs of electrons in the valency shell. This follows the approach originally suggested by Sidgwick and Powell[10]. On this model, the shapes of CH_4, NH_3 and H_2O are all based upon the tetrahedral arrangement, there being a total of four (bonds + lone pairs) in each case. The steady fall in the $H - X - H$ angle in the above sequence is explained by assuming that the repulsion lone pair : lone pair > lone pair : bond pair > bond pair : bond pair[11]. One can extend this picture to those transition metals the non-bonding d-shells of which are spherically symmetrical, elements with configurations d^0, d^5 (spin-free) and d^{10}. For ions with these configurations the shapes of complex molecules having no lone pairs are expected to be linear, triangular planar, tetrahedral, trigonal bipyramidal, octahedral and pentagonal bipyramidal, according as the co-ordination number is 2, 3, 4, 5, 6 or 7.

To appreciate the stereochemistry of complex ions with other than 0, 5 or 10 non-bonding d-electrons, the shapes of d-orbitals and their effect on the arrangement of the ligands must be considered. The ligand field theory assumes a purely electrostatic model for the calculation of energy effects; for example, the ion $[CoCl_4]^{2-}$ is regarded as a Co^{2+} surrounded by four Cl^- at the corners of a regular tetrahedron. Referred to orthogonal axes, the five d-orbitals may be divided into two classes; one class, the d_γ-orbitals, have lobes of electron density along

Table 1. CRYSTAL FIELD STABILIZATION* AND STEREOCHEMISTRY EXPECTED ON LIGAND FIELD THEORY (ALL SPIN-FREE)

No. of *d*-electrons	0, 5 or 10	1 or 6	2 or 7	3 or 8	4 or 9
Element and valency	(0) Ca^{2+}, Sc^{3+} (5) Mn^{2+}, Fe^{3+} (10) Zn^{2+}	(1) Ti^{3+} (6) Fe^{2+}	(2) Ti^{2+}, V^{3+} (7) Co^{2+}	(3) V^{2+}, Cr^{3+} (8) Ni^{2+}	(4) Cr^{2+}, Mn^{3+} (9) Cu^{2+}
Crystal field stabilization for perfect tetrahedron	0	$0{\cdot}6\ \Delta^1 = 0{\cdot}27\ \Delta$	$1{\cdot}2\ \Delta^1 = 0{\cdot}53\ \Delta$	$0{\cdot}8\ \Delta^1 = 0{\cdot}36\ \Delta$	$0{\cdot}4\ \Delta^1 = 0{\cdot}18\ \Delta$
Crystal field stabilization for perfect octahedron	0	$0{\cdot}4\ \Delta$	$0{\cdot}8\ \Delta$	$1{\cdot}2\ \Delta$	$0{\cdot}6\ \Delta$
Preferred stereochemistry	For shapes see text	Octahedron (very slightly distorted)	Regular tetrahedron, *or* octahedron (very slightly distorted)	Regular octahedron	Square planar *or* tetragonal

* $\Delta^1 = 4/9\ \Delta$

the *z*-axis (d_{z^2}) and along the *x*- and *y*-axes ($d_{x^2-y^2}$). The second class, d_ε orbitals, have their lobes of electron density in between the *x*-, *y*- and *z*-axes. There are three d_ε orbitals (d_{xy}, d_{xz} and d_{yz}) in the *xy*-, *xz*- and *yz*-planes, respectively. In an octahedral complex, these two classes of orbitals have different energies, the d_γ-doublet being of higher energy than the degenerate d_ε triplet. The lobes of electron density in the d_γ-orbitals point *towards* the ligands and in the d_ε-orbitals they point *between* the ligands. The separation Δ, or 10 Dq, between these degenerate levels is a measure of the strength of the electrical field produced by the ligands[3]. This is shown in Fig. 1*a*. For a tetrahedral complex the d_ε- and d_γ-levels are inverted since it is the d_ε orbitals which now point towards the ligands. The energy-levels are shown in Fig. 1*b*. In all cases the ligands are regarded as negative point charges.

When comparing complex ions of the same shape but having different numbers of *d*-electrons, this splitting leads to certain stabilization. Consider an octahedral complex of a d^1-ion, for example, Ti^{3+}. If the single *d*-electron were to spend 1/5 of its time in each of the five *d*-orbitals, its energy would be given by the point *A*. However, in fact, it is located in the d_ε-orbitals and the complex is more stable than the above hypothetical mean by an amount 4 Dq. This is the crystal field stabilization energy. For a tetrahedral complex, the value of Δ^1 is only 4/9 of Δ, and crystal field stabilization energies are consequently smaller for these complexes. Table 1 gives theoretical values for these crystal field stabilization energies.

We must take into account this effect in addition to the interactions between bonding pairs of electrons (σ-pairs) discussed earlier for spherically symmetrical metal ions. One expects to obtain a regular tetrahedron with the configurations d^0, d^2, d^5 (spin-free), d^7 (spin-free) and d^{10}, that is, when d_ε- and d_γ-shells in Fig. 1*b* are empty, half full or full. Tetragonal or square planar arrangements are expected for d^4 (spin-free) and d^9 configurations. Finally, all spin-free configurations except d^4 and d^9 should also give rise to a perfect or very slightly distorted octahedron. From ligand field theory the tetrahedral arrangement is expected to occur less frequently than the octahedral, since the crystal field stabilization energy is always larger in the latter case. These values are sometimes used as a means of assessing the relative ease of obtaining tetrahedral *vis-à-vis* octahedral complexes. However, we consider that there are so many other factors influencing the question that the value of crystal field stabilization energies for this purpose is limited.

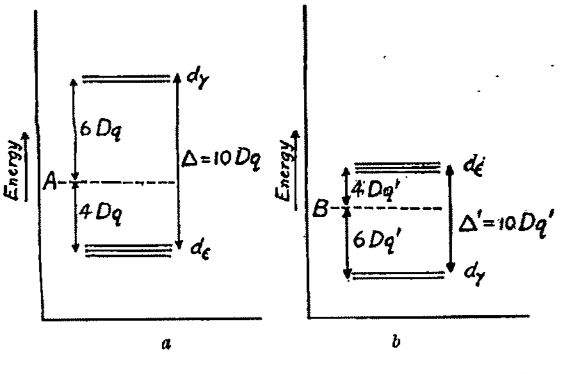

Fig. 1. Splitting of orbital levels in (*a*) octahedral complex; (*b*) tetrahedral complex, $\Delta^1 = 4/9\ \Delta$

We note that Orgel[3] has pointed out that, although crystal field splittings appear to be the important factors determining the relative stabilities of the tetrahedral and octahedral configurations, nevertheless these qualitative arguments may well prove deceptive; and he stressed the need for further testing of the theory.

First, even when using the purely electrostatic model, it needs to be emphasized that the energy required to assemble the field-producing arrangement is not the same. In other words, the positions *A* and *B* in Fig. 1 do not represent the same energy, and, indeed, the difference between these could be of even greater significance than the crystal field stabilization energy which is measured relative to these points. Secondly, these calculations ignore repulsions between ligands, and the fact that metal-ligand bond distances in octahedral and tetrahedral complexes are not usually the same.

The theory suggests that for electronic configurations other than d^0, d^2, d^5, d^7, d^{10} and also spin-paired d^4, a regular tetrahedral arrangement is much less probable than an octahedral, tetragonal or square planar one. Thus four-covalent spin-free Ni^{II} (d^8) and Fe^{II} (d^6) complexes are not expected to occur in a regular tetrahedral arrangement; but rather, if they occur at all, in a grossly distorted tetrahedron. There has long been speculation concerning the existence of tetrahedral Ni^{II} complexes. The usually accepted example, Ni^{II} *bis*-acetyl acetone[12,13], is now known to be a trimer almost certainly involving octahedrally co-ordinated nickel. Recently, however, Venanzi[14] has reported that complexes of the type $NiCl_2.2Ph_3P$ are monomeric in benzene, and hence the nickel atom is four-covalent; X-ray studies by Venanzi and Powell indicate that it is at the centre of a distorted tetrahedron[14]. This result is supported by the magnetic moment (3·1 B.M.), which is only slightly in excess of the spin-only value, 2·83 B.M., the orbital contribution being small. The latter should be large if the Ni^{II} is surrounded by a regular tetrahedron of negative charges. This arises because,

Table 2. ARSONIUM TETRACHLORO COMPLEXES OF TRANSITION METALS
General formula [Ph$_3$MeAs]$_2$[MCl$_4$]

Property	Metal					
	Mn^{II}	Fe^{II}	Co^{II}	Ni^{II}*	Cu^{II}	Zn^{II}
Colour	Pale green	Cream	Blue	Green blue	Yellow	White
Conductivity in PhNO$_2$ in r.o. (conc. ~ M/2,000) (20° C.)	57·0	Oxidizes	55·0	55·8	60·4	53·2
Magnetic moment at 20° C. (B.M.)	5·88	5·33	4·69	3·89	1·91	Diamag.

* The corresponding iodides of Mn^{II}, Fe^{II}, Co^{II} and Ni^{II}, for example, [Ph$_3$MeAs]$_2$ [NiI$_4$], have been prepared and are isomorphous. The nickel complex is red and again has a high magnetic moment (3·49 B.M.). With the tetraethylammonium cation similar behaviour is observed, the magnetic moments of [Et$_4$N]$_2$[NiCl$_4$] and [Et$_4$N]$_2$[NiBr$_4$] being in the range 3·8–3·9 B.M.

Table 3. PREDICTED MAGNETIC MOMENTS FOR SPIN-FREE BIVALENT NICKEL COMPOUNDS

Environment of Ni^{II} atom	$\mu_{eff.}$ (calculated)
(1) Free Ni^{++} ion ($^3F_4$). No electrical field. $S = 1, L = 3$ (assuming $h\nu = 0$)	4·47 B.M.
(2) As in (1) but using accepted value of $\nu = 2{,}347$ cm.$^{-1}$	5·56 B.M.
(3) As in (1) but assuming $h\nu = \infty$	5·59 B.M.
(4) Ni^{2+} ion in octahedral ligand field assuming no spin-orbital coupling	2·83 B.M.
(5) Octahedral Ni^{II}, for example, [Ni(H$_2$O)$_6$]$^{2+}$ or [Ni(NH$_3$)$_6$]$^{2+}$, using accepted value of spin-orbit coupling constant λ (varies from 200 to 324)	~ 3·1 – 3·2 B.M.
(6) Ni^{2+} ion in tetrahedral ligand field, assuming no spin–orbital coupling (taking $L = 1$)	3·16 B.M.
(7) As in (6), using the same value of λ as in the octahedral case but assuming that Δ is very large, that is, that the only configuration to be considered is $d_\gamma{}^4 d_\varepsilon{}^4$	3·6 B.M.*

* We are indebted for this figure to Dr. B. N. Figgis, who also reports that if Δ is not large enough to preclude configuration interaction, then the moment may be as large as 4·2 B.M. (unpublished work).

in order to obtain a large orbital contribution to the magnetic moment, one must have the possibility of re-arrangement of electrons in d_ε-orbitals when a magnetic field is applied. Three degenerate d_ε-orbitals containing a total of four electrons, as occurs for the Ni^{II} atom in a regular tetrahedral complex, provides an ideal example of this. A probable example of tetrahedral Fe^{II} occurs in the compound[15] FeI$_2$.2Ph$_3$P.

We have recently been studying complexes of the type M(hal)$_2$.2 pyridine of those bivalent metals which should give rise to both regular tetrahedral and octahedral arrangements; for example, Mn^{II}(d^5), Co^{II}(d^7) and Zn^{II}(d^{10}). In this connexion we have prepared compounds of the type [Ph$_3$CH$_3$As]$_2$+ M (hal)$_4$$^{2-}$, where hal = Cl, Br and I. These are obtained readily by adding the arsonium halide to the metal halide in alcoholic solution. In addition to the tetrahalide complexes of the metals listed above, we have obtained those of Fe^{II}, Ni^{II} and Cu^{II}. These are listed in Table 2. The Mn^{II}, Co^{II} and Zn^{II} complexes have the properties expected for four-covalent tetrahedral anions. The compounds are electrolytes in nitrobenzene, with the conductance expected for bi-univalent electrolytes. Only in the case of the Co^{II} compound is the orbital contribution to the magnetic moment helpful in deciding stereochemistry. The tetrahedral structure of the [CoCl$_4$]$^{2-}$ ion has been established in the compounds Cs$_3$CoCl$_5$ (ref. 16) and Cs$_2$CoCl$_4$ (ref. 17), the magnetic moments of which are close to that observed for [Ph$_3$MeAs]$_2$ CoCl$_4$. However, the magnetic moment of the Ni^{II} compound, 3·89 B.M.*, is unusually high; this points strongly to a tetrahedral arrangement of the ligands about the Ni^{II}. Moreover, for the orbital contribution to be so large, distortion from a regular tetrahedral arrangement is small. The expected magnetic moment for a tetrahedral Ni^{II} complex can only be calculated roughly owing to uncertainty as to the splitting, Δ, and the spin-orbit coupling constant. In Table 3 we list the calculated moments for Ni^{II} in various circumstances. The octahedral case has been carefully examined by Griffiths and Owen[18], who also emphasize that charge transfer between metal and ligand in metal hydrates occurs owing to weak σ-bonding.

The conclusion that these complex ions are tetrahedral is supported by X-ray diffraction investigations of single crystals of the compounds. With the exception of the Cu^{II} compound, which is expected to contain a tetragonal or square complex ion, the compounds of Mn^{II}, Fe^{II}, Co^{II}, Ni^{II}, and Zn^{II} are isomorphous, forming cubic crystals with cell edge 15·5 A. (Ni), space group $P2_13$, with four molecules in the unit cell. Though there are slight differences in cell constants, the intensities of corresponding diffraction maxima of the several compounds appear substantially the same, strongly indicating a regular tetrahedral arrangement for the Ni^{II} and Fe^{II} complexes, having accepted such arrangement for the Mn^{II}, Co^{II} and Zn^{II} complexes. Furthermore, the crystal symmetry is such that the metal atom lies on a three-fold axis, and taken in conjunction with the results of our other physical-chemical experiments, we conclude that it is surrounded by three equivalent chloride ions and one non-equivalent chloride ion also on the three-fold axis. The magnetic behaviour of [Ph$_4$As]$_2$ [NiCl$_4$] in a suitable non-co-ordinating solvent should prove of interest, because under these conditions the constraining effects, if any, of the lattice of neighbouring ions will be removed.

These investigations are being extended to include other bivalent and tervalent metals, and to complete the crystal structure determination of [Ph$_3$MeAs]$_2$ [NiCl$_4$]. The important feature which emerges from these studies is that when considering cases where crystal field forces are opposed by others, particularly those arising from bonds, the crystal field forces may be swamped and the structure be that determined by bond and lattice interactions.

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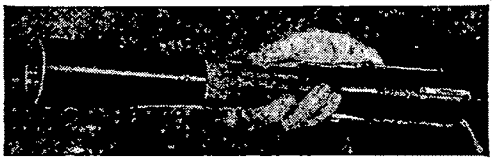

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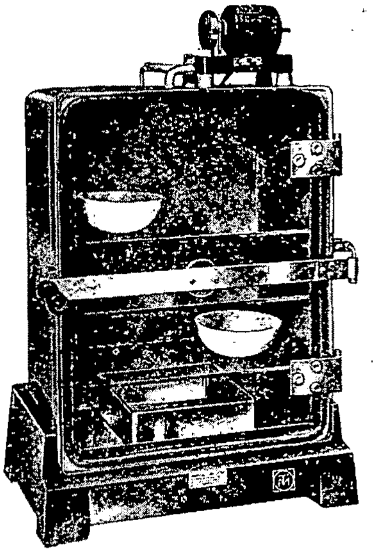

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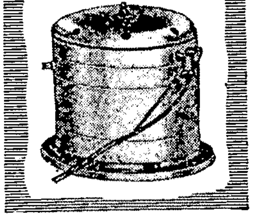

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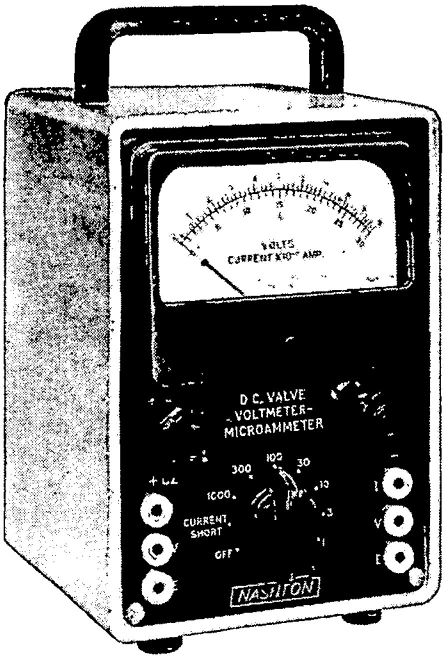

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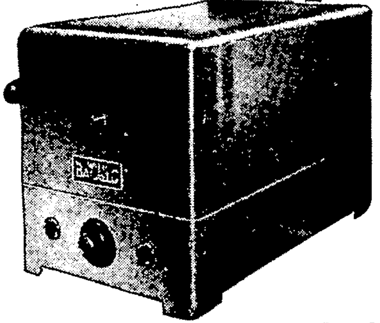

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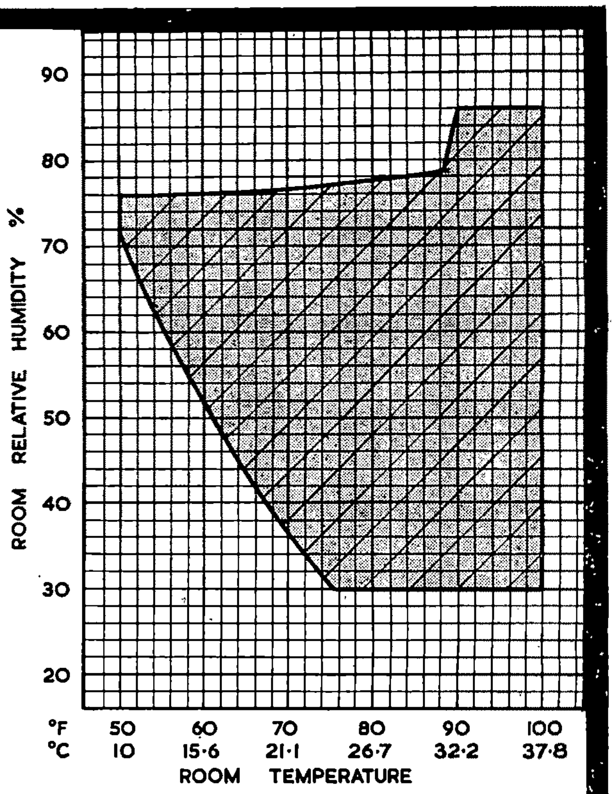

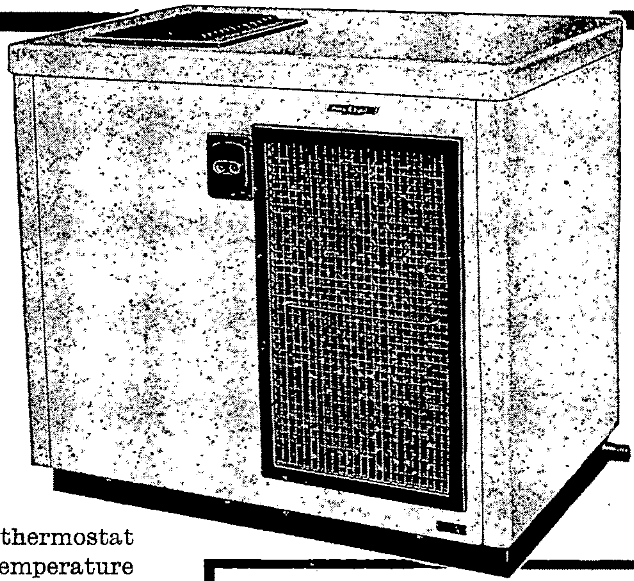

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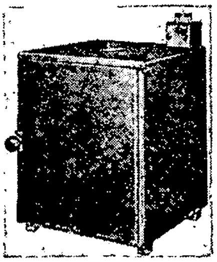

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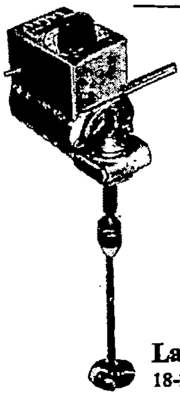

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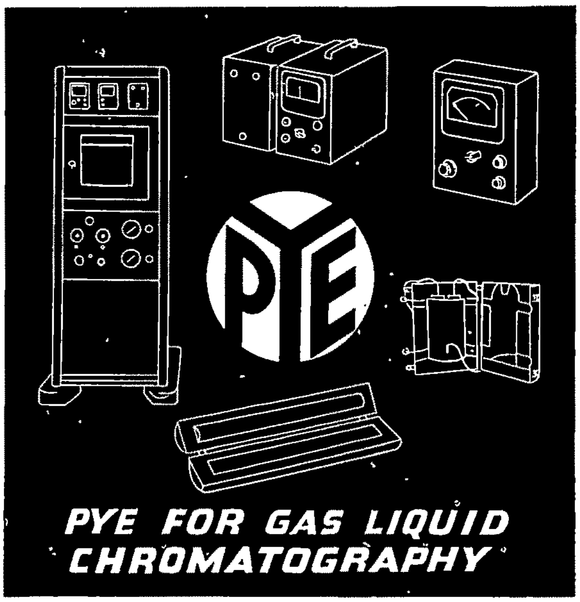
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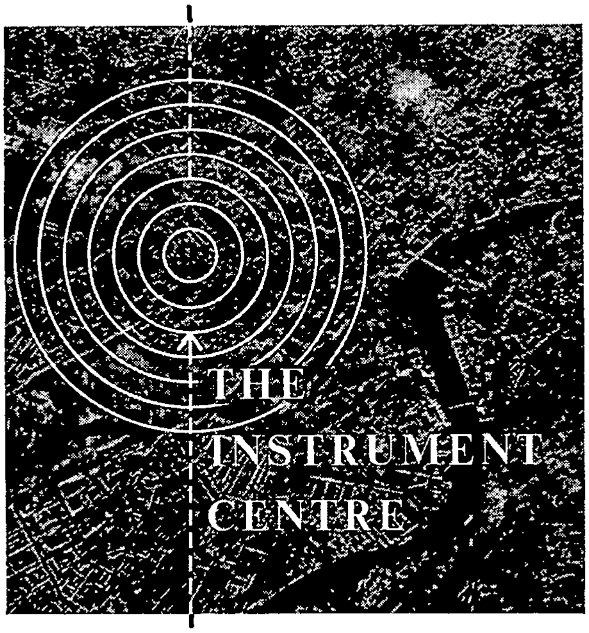

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Some Genetic and Physiological Aspects of Two Different Adult Hæmoglobins in Sheep

INVESTIGATING more than 4,500 sheep of different breeds, Harris and Warren *et al.*[1–3] described the presence of two electrophoretically different types of adult hæmoglobin. The hæmoglobin moving more rapidly towards the anode at *p*H 8·6 was called Hb-*A* and the slower migrating component Hb-*B*. The occurrence of the two sheep hæmoglobins appears to be genetically determined by two genes, each responsible for the formation of one type of hæmoglobin. Large differences in the relative frequencies of the two types of sheep hæmoglobin were found from breed to breed; the lowland breeds have predominantly the Hb-*B* type and the highland breeds the Hb-*A* type. Two types of adult hæmoglobin were also found in Dutch sheep (Texel breed)[4]. They are designated Hb-I (slow-moving in paper electrophoresis) and Hb-II (fast-moving hæmoglobin). It is not known whether these two types of hæmoglobin are identical with the hæmoglobins *B* and *A*, respectively, but the electrophoretic patterns are closely similar, and moreover, the Dutch breed is closely related to some English breeds, such as Leicester and Lincoln. Studying the physical and chemical properties of the two hæmoglobins[4], differences were found in their resistance to denaturation by alkali, in electrophoretic and chromatographic behaviour, in solubility in concentrated salt solutions and in amino-acid composition.

The incidence of the two types of hæmoglobin in 300 sheep of the Texel breed has been determined. 71 per cent of these animals had hæmoglobin of type Hb-I, 3 per cent Hb-II and 26 per cent both types. These values are of little importance, as the genetic pattern of one breeding ram strongly influences the gene frequencies in a herd.

Blood samples from 80 animals belonging to one pedigree were also examined. The results are given in Fig. 1. The first ram, used in 1954 and in 1955, was homozygous for Hb-I; three of the five ewes (year 1954) and four of the five ewes of 1955 were heterozygous for both hæmoglobins I and II. The gene responsible for the production of Hb-II was transmitted to about half their descendants. One of the male lambs, born in 1954 and heterozygous for Hb-I and II, was used as breeding-ram in 1956 and 1957. Many ewes being impregnated by this ram were heterozygous for the two hæmoglobins. So it was possible to get figures on the inheritance of both types of hæmoglobin. The results shown in Table 1 indicate that the two types of hæmoglobin are inherited in a simple Mendelian manner, resembling the genetic pattern of some types of human hæmoglobin.

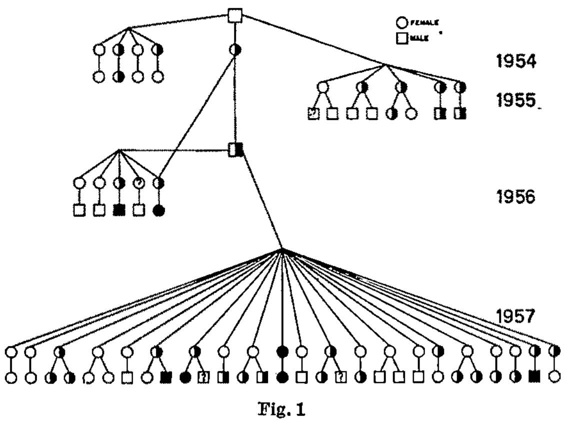

Fig. 1

Table 1. GENETIC PATTERN OF THE TWO SHEEP HÆMOGLOBINS I AND II
The values in parentheses indicate the expected numbers of lambs belonging to one of the three combinations

Male	Female		Lambs			
		No.	Total	I and I	I and II	II and II
I + I	I + II	13	18	7 (9)	11 (9)	
I + II	I + I	27	35	18 (17–18)	17 (17–18)	
I + II	I + II	10	12	3 (3)	4 (6)	5 (3)

During these investigations, it was observed that samples of venous blood (obtained by puncture of the vena saphena) of sheep homozygous for Hb-II seemed to be oxygenated to a greater extent than were the corresponding blood samples of sheep homozygous for Hb-I. Analyses of the oxygen saturation[5] of a few samples of venous blood showed values of 85, 87 and 90 per cent for the sheep homozygous for Hb-II, and 69, 72 and 75 per cent for the sheep homozygous for Hb-I. These preliminary results prompted us to study the oxygen affinities of the blood from the two types of sheep as well as of the hæmoglobins in solution. Small samples of blood (1·0 ml.) in a tonometer of 150 ml. capacity[6] were exposed to various gas mixtures containing known percentages of oxygen and a fixed percentage (40 mm. mercury) of carbon dioxide. Equilibration was obtained by rotation of the tonometer in a water-bath at 37° C. for 20 min. The percentage saturation with oxygen was measured spectrophotometrically[5], and the *p*H values of the samples were also determined. Hæmoglobin solutions were prepared by laking fresh, washed erythrocytes with an equal volume of distilled water and 0·4 vol. of toluene for 3 hr. at 2° C., followed by centrifugation at high speed in the cold for 30 min. Following the technique described by Allen *et al.*[7], both hæmoglobin solutions were dialysed for 16 hr. simultaneously against the same sample of 0·4 *M* phosphate buffer of *p*H 7·5, containing 1·0 *M* glucose. The oxygen affinities of these hæmoglobin solutions, containing hæmoglobin in a concentration varying between 14 and 17 gm. per 100 ml., were measured using the same method as described for the blood samples. Possible modifications of the oxygen saturation of the samples pro-

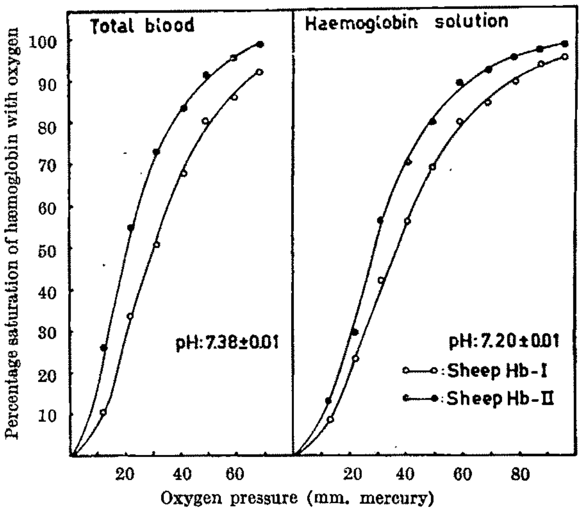

Fig. 2. Oxygen dissociation curves of the two sheep hæmoglobins

duced by differences in the carbon dioxide tension of the blood and hæmoglobin sample or by deviations in the pH could be excluded, since a constant carbon dioxide tension (40 mm. mercury) was applied and the pH values of the samples after equilibration varied only within narrow limits (± 0·01).

Fig. 2 illustrates the results. It was found that the oxygen dissociation curve of the blood obtained from a sheep homozygous for Hb-II was shifted to the left, indicating a higher oxygen affinity of blood of type Hb-II. This finding may be explained by intrinsic differences of the hæmoglobin molecule rather than by differences in the environment of the hæmoglobin, since the oxygen affinities of the dialysed solution of blood of type Hb-II were consistently higher than those of the corresponding dialysed solution of blood of type Hb-I. These results suggest that hæmoglobin of type Hb-II has adaptive significance and may have originated by mutation in sheep living at high altitude. It is worth noticing that the frequency of hæmoglobin of type Hb-*A* described by Evans *et al.*[3], which is probably identical with our Hb-II, is relatively high in the mountain and hill breeds, suggesting predominance of these animals by natural and human selection. This is remarkable, as any advantage in possessing this type of hæmoglobin with increased oxygen affinity can scarcely be assumed at this moderate altitude.

The increased oxygen affinity allows the blood of a sheep of hæmoglobin type Hb-II living at sea-level to take up more oxygen in the lungs, but also hampers the liberation of the oxygen from the blood in the tissues. So the oxygen, which is present in the blood, is less available to the tissues, resulting in an anoxia. Consequently, an increase of the total hæmoglobin content of the blood may occur. Table 2 illustrates a significantly higher total hæmoglobin content of the blood of the sheep of type Hb-II compared with the values found in sheep of type Hb-I. The values found in sheep heterozygous for both hæmoglobins are intermediate.

Table 2. TOTAL HÆMOGLOBIN LEVELS OF THE BLOOD OF LAMBS TWO MONTHS OLD POSSESSING THE TWO DIFFERENT HÆMOGLOBINS

Type	No.	Hæmoglobin (gm. per 100 ml.)	*P*-value
Hb-I	70	11·7 ± 0·1	I to I/II < 0·01
Hb-I + Hb-II	25	12·2 ± 0·15	I to II < 0·001
Hb-II	4	13·2 ± 0·15	I/II to II < 0·01

The different oxygen affinities may also offer an explanation for deviations in the relative amounts of the two hæmoglobins in sheep heterozygous for the Hb-I and Hb-II, when these animals are suffering from a severe anæmia, caused, for example, by chronic strongylosis and distomatosis. It was found (Table 3) that a decrease of the total hæmoglobin content from 11 gm. per 100 ml. to 8 gm. per 100 ml. is compensated by an increased production of hæmoglobin of type Hb-II, increasing the capacity of the blood for oxygen. When, however, the total hæmoglobin content is decreased to very low values (2–4 gm. per 100 ml.), increased production of Hb-I occurs, which facilitates the liberation of oxygen from the blood to the tissues.

Table 3. RELATION BETWEEN THE TOTAL AMOUNT OF HÆMOGLOBIN AND THE PERCENTAGES OF THE TWO ADULT HÆMOGLOBINS IN SHEEP HETEROZYGOUS FOR BOTH TYPES

Sheep	Total hæmoglobin (gm. per cent)	Hb-I (per cent)	Hb-II (per cent)
A	11·2	56	44
B	8·4	36	64
C	4·2	70	30
D	1·8	76	24

It is evident from this work that the presence of two different types of hæmoglobin in the adult sheep is a genetically controlled abnormality of hæmoglobin synthesis. The increased oxygen affinity found for hæmoglobin of type Hb-I may offer an explanation for its origination in sheep living at high altitude.

These investigations were supported by a grant of the Dutch Organization for Pure Research (Z.W.O).

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Hæmoglobin Types in Different Species of Sheep

IN previous reports[1,2] we described some characteristic properties of two different hæmoglobins (called Hb-I and Hb-II) in Dutch sheep (Texel breed), which are probably identical with the sheep hæmoglobins *B* and *A* discovered by Harris, Warren *et al.*[3-5]. Hb-II is distinguished from Hb-I by its electrophoretic and chromatographic behaviour, by a higher resistance to denaturation by alkali, a decreased solubility in concentrated phosphate solutions, and a different amino-acid composition[1]. Moreover, erythrocytes, as well as dialysed hæmoglobin solutions of sheep homozygous for Hb-II, show an increased affinity for oxygen[2]. These results suggest that Hb-II is of adaptive significance and that this hæmoglobin-type originated in domesticated breeds from sheep living at high altitude.

To confirm this hypothesis we studied blood samples from some different species of sheep living

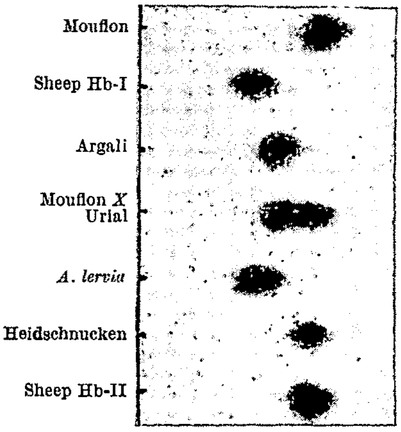

Fig. 1. Paper-electrophoretic separation of the hæmoglobins of different species of sheep

in the Zoological Gardens, Artis (Amsterdam) and Blijdorp (Rotterdam). We examined the following species of the genus *Ovis*: the Argali (*Ovis ammon*), living in the mountains of North and Central Asia above the timber-line; the European Mouflon (*Ovis musimon*), originally living in South and Central Europe and at present in the mountains and forests of Corsica and Sardinia; a cross-bred between the Mouflon and the Urial (*Ovis vignei*) and the Heidschnucken, a native breed of the Lüneburger Heide (Germany) which is most probably descended from the European Mouflon. One species of the genus *Ammotragus* (*A. lervia*), which lives in the mountains of North Africa, was also investigated. The hæmoglobins from one Argali, five Mouflons, one cross between the Mouflon and the Urial, four Heidschnucken and two *A. lervia* were examined by denaturation with alkali, by paper electrophoresis (0·06 *M* veronal buffer solution of *p*H 8·8) and by salting-out experiments. The oxygen dissociation curves of the total blood samples as well as of the hæmoglobin solutions were also established. The techniques used are described in previous papers[1,2].

The hæmoglobins of the different sheep showed the same high resistance to denaturation by alkali found for Hb-II, indicating that none of them is identical with Hb-I. The results of the paper-electrophoretic examination of the hæmoglobins are shown in Fig. 1. The hæmoglobins of the Mouflon and of the Heidschnucken show the same fast electrophoretic mobility found for Hb-II; the hæmoglobin of the cross between the Mouflon and the Urial consists of two components, the fast moving one being identical with that of the Mouflon. The hæmoglobin of the Argali moves slightly faster than Hb-I and shows almost the same mobility as the second component of the cross, probably the hæmoglobin of the Urial. Finally, the hæmoglobin of *A. lervia* can scarcely be differentiated from Hb-I.

The solubilities of Hb-I, and the hæmoglobins of the Mouflon, Argali and *A. lervia* in phosphate buffers of different concentrations are given in Table 1. The hæmoglobin of the Mouflon and Hb-II show the same low solubility; these hæmoglobins are completely insoluble in 2·8 *M* phosphate buffer. The solubilities of the hæmoglobins of the Argali and of *A. lervia* are intermediate between those of Hb-I and Hb-II, but they are not identical.

Table 1. SOLUBILITY AS PERCENTAGE IN SOLUTION OF SHEEP HÆMOGLOBINS IN PHOSPHATE BUFFERS (*p*H 6·5) OF DIFFERENT MOLARITIES

Species	2·10 *M*	2·59 *M*	2·80 *M*	2·94 *M*
Dutch Sheep Hb-I	100	100	90·5	24·0
Dutch sheep Hb-II	100	39·3	0·2	0
Mouflon	100	48·5	3·5	0·1
Argali	100	92·1	10·9	0·1
A. lervia	100	96·2	24·6	20·3

The oxygen dissociation curves of the total blood samples and of the dialysed hæmoglobin solutions are shown in Fig. 2. The oxygen affinities of the blood of the Mouflon and of the Heidschnucken are identical with that of sheep homozygous for Hb-II. The oxygen affinity of the blood of the Argali is still greater, while the oxygen dissociation curve of the blood of *A. lervia* is intermediate between those of the blood derived from sheep homozygous for Hb-II and Hb-I. Similar results were obtained for dialysed hæmoglobin solutions, indicating that the differences in oxygen affinity are inherent in intrinsic differences of the hæmoglobin molecules rather than due to differences in their environment.

From these results it may be concluded that Hb-II in the breed 'Texel' originated in the (European) Mouflon, confirming the generally accepted opinion that Dutch sheep (and perhaps also English sheep) are partially descended from this animal[6]. The Heideschnucke also possesses Hb-II. In none of the species investigated was Hb-I present. This hæmoglobin in Dutch sheep may therefore have originated in other types, for example Lincoln and Leicester sheep, which possess Hb-I only (unpublished results). The descent of these sheep is unknown. The presence of Hb-I in these breeds may have been derived from an unknown species living at sea-level.

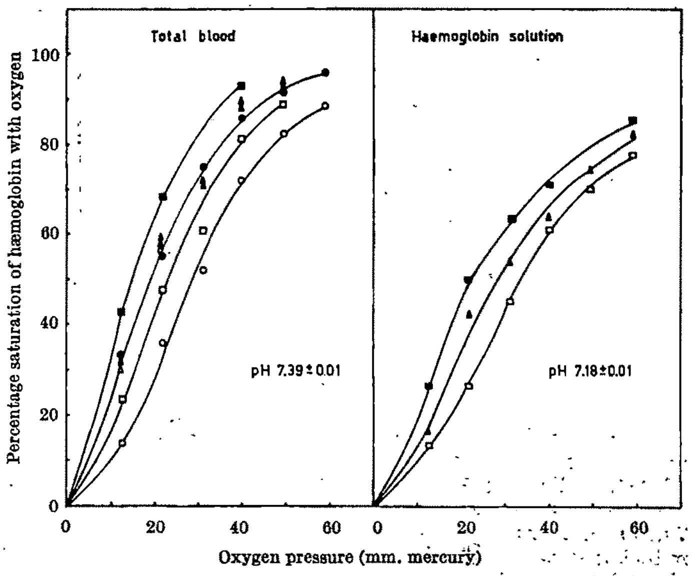

Fig. 2. Oxygen dissociation curves of blood samples of sheep: ○—○, Dutch sheep, breed 'Texel', homozygous for Hb-I; ●—●, Dutch sheep, breed 'Texel', homozygous for Hb-II; □—□ *A. lervia*; ■—■, Argali; △—△, Heidschnucken; ▲—▲, Mouflon

It is remarkable that sheep living at high altitude (Argali) possess a hæmoglobin type with an oxygen affinity still greater than that of the Mouflon, while *A. lervia*, living at about 1,000 m. above sea-level, possess a hæmoglobin the oxygen dissociation curve of which is between those of Hb-II and Hb-I. It seems, therefore, that a specific type of hæmoglobin is present in these animals with its own chemical and physiological properties. Thus four different types of hæmoglobin can be demonstrated in sheep; in the genus *Ovis* besides Hb-I and Hb-II (identical with the hæmoglobin of the Mouflon) there is the hæmoglobin of the Argali, and in the genus *Ammotragus* the hæmoglobin of *A. lervia*.

These investigations were supported by a grant of the Dutch Organisation for Pure Research (Z.W.O.). We are much indebted to Drs. Jacobi (Artis, Amsterdam) and van Bemmel (Blijdorp, Rotterdam) for their aid in collecting the blood samples from the different animals.

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VASCULAR PERMEABILITY FACTORS IN THE SECRETION OF THE GUINEA PIG COAGULATING GLAND

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THE secretion of the coagulating gland of the male guinea pig induces a hypotensive shock on intravenous injection into the guinea pig and the rabbit, and œdema on local injection into the tissues[1].

The induction of œdema suggested that these effects were produced by substances increasing the permeability of the blood vessels. By preparative starch electrophoresis[2] in phosphate buffer at *p*H 8·0, we have isolated two main protein components (fractions I and II) from the fluid. Fraction I is hypotensive and a highly potent permeability factor in the guinea pig and rabbit; fraction II coagulates the contents of the seminal vesicles and is a moderately potent permeability factor in the rat and the rabbit, owing its activity in the rat to the liberation of histamine. Neither is a 'spreading-factor' in connective tissue.

The fluid was harvested from large numbers of animals and freeze-dried. On reconstitution to the original volume in water, a small portion of the material was insoluble and discarded. The soluble portion contained 150 mgm./ml. protein, in which five components (fractions 0, I, II, III, IV in descending order of mobility) were separated by paper electrophoretic analysis[3]. Fractions 0, III and IV represented 1, 10 and 4 per cent of the total protein, and had no substantial toxic or coagulating activity. Fractions I and II represented 16 and 69 per cent of the total proteins, respectively; although by starch electrophoresis the percentage yields of the two protein fractions were nearly equal.

Fraction I had an electrophoretic mobility rather greater than that of guinea pig serum albumin. It was homogeneous in the ultracentrifuge with an S_{20w} of 4·4, indicating—on the assumption of an isodiametric molecule—a molecular weight of about 70,000. On hydrolysis it yielded some 11 per cent of reducing sugars. It had feeble caseinolytic activity[4], about 1/5000 that of crystalline trypsin, disappearing on storage even at − 10° C., and contained a strong *p*-toluenesulphonylarginine methyl esterase[5], which had the same stability to heat as the permeability factor (losing only 20 per cent of its activity after 5 min. at 95° C.) and it was not antagonized by soya-bean trypsin inhibitor.

The permeability-increasing potency, measured in terms of blue exudation into the skin of animals with pontamine blue in their circulation, is expressed in Table 1 as the number of 'effective blueing doses'[6,7] per mgm. Fraction I is highly active in the guinea pig, and even more so in the rabbit; in both animals it was not inhibited by soya-bean trypsin inhibitor, and only slightly inhibited by mepyramine maleate and by the guinea pig serum fraction containing inhibitor of the serum permeability factor[9]; in the rat peritoneal cavity[10] it did not liberate histamine.

Table 1

Preparation	Effective blueing doses per mgm. in: Guinea pig	Rat	Rabbit
Original fluid (guinea pig)	20,000	1,100	200,000
Fraction I	50,000	50	600,000
Fraction II	500	1,300	4,000
Histamine (ref. 8)	32,000	1,400	37,000

Injected intravenously, it reproduced the effects described by Freund and Thompson[1] for the whole gland fluid; doses of 2–4 mgm./kgm. body-weight induced moderate shock in the guinea pig and rabbit, which in the guinea pig was slightly lessened by systemic mepyramine; whereas 16 mgm./kgm. had little effect in the rat.

Fraction II had three times the coagulating potency of the original fluid, but no caseinolytic or arginine esterase activity. The main observations of Gotterer and others[11] on the nature of the coagulating principle were confirmed. Intravenous doses of 2–4 mgm./kgm. were non-toxic to guinea pigs, and 4–7 mgm./kgm. were only slightly toxic to rabbits; but in rats 10–16 mgm./kgm. induced an effect like that of egg-white[12], including œdema of the snout.

In the rat, fraction II appears to owe its activity to the release of histamine, since its permeability effect was inhibited by mepyramine; and it liberated histamine in the rat peritoneal cavity[10], in this respect being about equipotent with the synthetic histamine liberator, compound 48/80 (ref. 13).

The increase in permeability induced by fraction II in the rat, like that of fraction I in the guinea pig and rabbit, was not affected by dialysis in 'Cellophane' sacs.

It is of interest that starch-block electrophoresis of the fluid from the *rat* coagulating gland yielded only two protein fractions, which had about the same respective mobilities as fractions I and II of the guinea pig fluid. Neither fraction was toxic to, nor had a significant permeability effect in, the three test animals. As in guinea pig gland fluid, the coagulating activity was present in the less mobile fraction II. The analogous status of rat and guinea pig fractions II is strengthened by the fact that each was capable of coagulating the seminal vesicular material from the other species.

Our results are consistent with the view that the main toxin, for guinea pig and rabbit, of fluid from the coagulating gland of the guinea pig is the permeability factor in fraction I, which appears to be a glycoprotein with arginine esterase activity. This toxin is in many important features unlike the globulin permeability factors in human[14] and other mammalian sera[7,9]. The permeability-increasing potency is negligible in the rat. On a weight basis, it is nearly twice that of histamine in the guinea pig; and in the rabbit it is outstanding among the potencies of all natural and synthetic permeability factors we have tested, being sixteen times that of histamine. On a molar basis, the protein of fraction I is, in these two animals, respectively 1,000 and 9,000 times as potent as histamine, suggesting an enzymic mode of action.

That fraction I is toxic for the homologous animal, particularly for the small blood-vessels, may be irrelevant to its function in the external glandular secretion of which it is a constituent; but its pharmacology may provide a clue to the mode of action of the enzyme-like, protein permeability factors present in blood and tissue fluids[15].

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SODIUM FLUOROACETATE AS A PROTECTING AGENT AGAINST IRRADIATION

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THE mortality as well as the somatic damage caused to living organisms by X- or γ-rays are greatly reduced by the previous administration of various compounds. To be effective, these substances must be injected into the animal immediately before irradiation. Cysteine, cysteamine and its derivatives were found to be most potent in this respect; many other compounds were also found to be effective (see refs. 1 and 2 for a review of the literature).

It now appears that deoxyribonuclease plays an important part in the destruction of deoxyribonucleic acid that follows irradiation. Deoxyribonucleic acid is localized in the cell nucleus, whereas acid deoxyribonuclease was found by de Duve *et al.*[3] to be concentrated in the small mitochondria, also called lysosomes. 'Neutral' deoxyribonuclease requires magnesium ions for its activity[4]. Therefore, it was thought that agents complexing magnesium ions would affect the activity of the enzyme and might protect against irradiation. Attempts to do so by intraperitoneal injections of large doses of sodium citrate (up to 1·25 gm./kgm.) to the mouse failed: very irregular results were obtained[5], presumably because injected citrate penetrates many tissue barriers with great difficulty (see ref. 6). Other chelating agents such as diethyldithiocarbamate and ethylenediamine tetraacetate, however, were found to protect mice against irradiation[7].

The administration of sodium fluoroacetate was known from the work of Peters and collaborators[8] (see also ref. 9) to accumulate citrate in animal tissues. The following experiments were performed to see whether the intracellular accumulation of citrate produced by the injection of fluoroacetate would protect the mouse against irradiation.

Lots of 10 mice of the *C57* black pure strain and weighing 18–22 gm. were given 750–775 r. at the average rate of 90 r./min., using a Siemens 200-kV. 'Stabilivolt'. Sodium fluoroacetate (Monsanto), when used, was injected intraperitoneally at a dose of 4–5 mgm./kgm. The toxicity of fluoroacetate for our mice was measured by the 'up-and-down' method of Dixon and Moore[10], as described by Kimball *et al.*[11]: LD_{50} was found to be $8 \cdot 3 \pm 1 \cdot 4$ (standard error) mgm./kgm. In our experiments, 4–5 mgm. sodium fluoroacetate/kgm. killed about 30 per cent of the control mice within 48 hr. To distinguish between that early death and death by irradiation which occurs later, the number of surviving animals was expressed as a percentage of those which survived after the first two days.

If injected 5 hr. or even 2 hr. before irradiation, sodium fluoroacetate reduced the mortality produced by X-irradiations (see Fig. 1). After 7 days, 42 per cent of the irradiated mice had died, whereas mice pre-injected with sodium fluoroacetate were all alive; after 14 days, the mortality figures for the two groups were 90 and 20 per cent; after 21 days, 94 and 40 per cent. It will be seen in Fig. 1 that sodium fluoroacetate given just before or just after irradiations is without effect on the mortality, which reaches 47·5, 90·5 and 95 per cent after 1, 2 or 3 weeks. In other series, sodium fluoroacetate was injected 24 hr. before, or 5 hr. after, irradiation; no protection was observed in either case.

It is now believed that fluoroacetate is not toxic by itself but only after it has been transformed into fluorocitrate, a competitive inhibitor of aconitase, an enzyme of the tricarboxylic acid cycle (for a review, see ref. 12). Accumulation of citrate in the tissues of the rat follows after a latent period[13] of 30–60 min.; the highest level of citrate in the tissues of the rat was observed 2–8 hr. after the injection of non-lethal doses of the poison[13,14].

The curves of Fig. 2 show that the tissues of the mouse behave like the tissues of the rat: sodium fluoroacetate produces an accumulation of citrate (curve *A*) with a maximum 2–14 hr. after the injection of the poison. Irradiation 5 hr. after injection of sodium fluoroacetate (curve *B*) reduces the level of accumulated citrate, which returns to normal level within 24 hr., whereas 48 hr. are required in the case of non-irradiated mice. Irradiation alone (curve *C*) produces no measurable change in the citric acid content of the tissues. When the mice are irradiated immediately after injection of sodium fluoroacetate (curve *D*), accumulation of citrate seems to be somewhat delayed, at least in the kidneys; high levels are reached as in sodium fluoroacetate controls, followed by a more rapid return to normal.

Fairly similar results were observed in spleen and brain. In heart, however, the antagonizing effect of X-rays on the accumulation of citrate induced by sodium fluoroacetate was less noticeable; the disappearance of citric acid under the influence of X-rays was delayed in that radio-resistant organ.

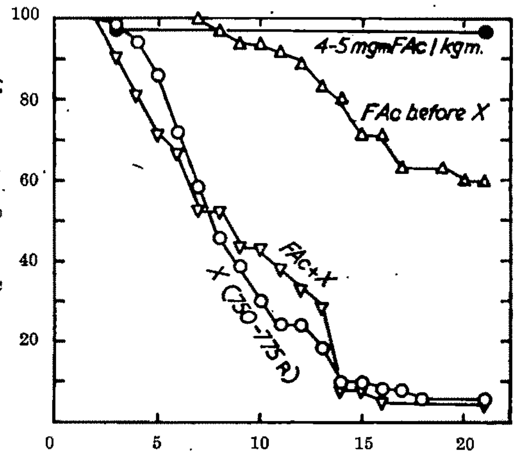

Fig. 1. Protection of the mouse against irradiation (*X*) by sodium fluoroacetate (*FAc*) injected 5 hr. before. The number of animals used in each experiment was: 4–5 mgm. *FAc*/kgm., 45; *X* (750–775 r.), 50; *FAc* before *X*, 40; *FAc* + *X* (simultaneously), 50

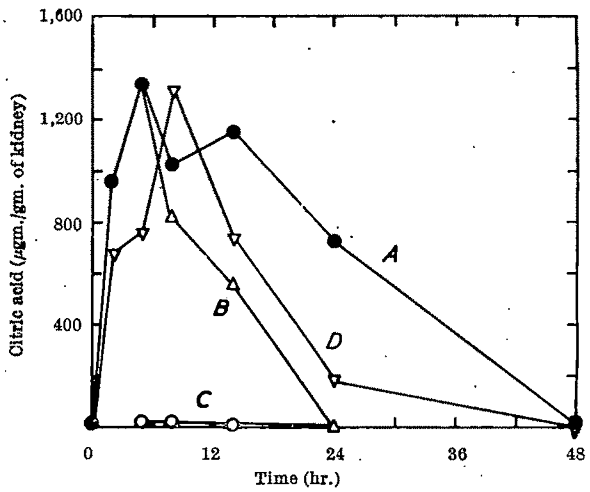

Fig. 2. Citric acid content of the mouse kidney. Curve *A*, sodium fluoroacetate only, 5 mgm./kgm.); curve *B*, 775 r. given 5 hr. after sodium fluoroacetate; curve *C*, 775 r. only; curve *D*, 775 r. given immediately after sodium fluoroacetate. Citric acid was estimated by the method of Taylor (ref. 16)

Our observations on the effects of sodium fluoroacetate and X-rays on the citric acid content of the tissues of the mouth are comparable to the results published by DuBois *et al.*[15], who demonstrated that rats, guinea pigs and mice receiving sodium fluoroacetate 3 hr. or more after irradiation accumulate less citrate than non-irradiated controls.

It may very well be that fluoroacetate somehow affects the sensitivity of the cells to X-rays by reducing their oxidative metabolism; many of the so-called radio-protectors are, in fact, toxic agents. Fluoroacetate may, however, protect the cells in a more specific way, accumulating citrate, complexing the intracellular magnesium ions, and so affecting the deoxyribonuclease activity, as we have supposed: such a mechanism, still very speculative indeed, is supported by the results of our experiments, although not proved, of course. If the availability of free magnesium ions must be reduced to afford radio-protection, it would seem from the evidence presented here that such a reduction must be completed at the very moment of the irradiation; sodium fluoroacetate injected only at that time piles up citrate too late, and no longer protects.

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LETTERS TO THE EDITORS

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A Revision of the Azulene Structure

In a previous communication from this laboratory[1], a crystal structure for azulene based on the non-centrosymmetric space group *Pa* was reported. It was assumed that the (0*k*0) halving was accidental and it was easy to place the two molecules with respect to the glide plane in such a way that an almost exact halving of these spectra was obtained. This structure led to reasonably good agreements in all the principal zones, the discrepancies between observed and calculated structure factors being about 12 per cent for (*h*0*l*), 14 per cent for (*hk*0) and 20 per cent for (0*kl*). A convincing electron density map for the projection on (010) was obtained, and it was confidently expected that a further analysis of the full three-dimensional crystal data would lead to a complete refinement of the structure, with significant values for the bond-lengths and electron distribution. Our preliminary structure was further supported by an independent investigation made by Takeuchi and Pepinsky[2], who obtained almost identical results. Neither of us saw any evidence of disorder in our X-ray photographs, although Günthard[3] has shown from a comparison of the entropies of azulene and naphthalene that there may be some disorder in the azulene crystal.

We now find that our preliminary structure is wrong, or at least it constitutes only half the truth, and the structure must in fact be disordered, as postulated by Günthard. This is one of the most remarkable examples that we have encountered of a preliminary structure based on data from three crystallographic zones being wrong in spite of quite reasonably good agreements in the structure factor calculations.

When we proceeded to refine the structure from our full three-dimensional data it was not long before we encountered difficulty. Various difference syntheses and generalized projections did not lead to much refinement, and after these had been carried out the average discrepancies between calculated and observed structure factors over all the 670 observed (*hkl*) reflexions was 23·4 per cent. With the help of Prof. Ray Pepinsky and Dr. V. Vand we then attempted a least squares refinement of the three-dimensional data, but after three cycles of such refinement the average discrepancy only decreased to 22·4 per cent.

Something was clearly wrong, so we next examined the possibility that the space group might after all be $P2_1/a$, as indicated by the halvings, and the structure really centrosymmetric. The atomic co-ordinates deduced previously were referred to a new origin at the centre of the molecule which was taken to coincide with a centre of symmetry in $P2_1/a$, and the atoms were given half-weight. This procedure postulates the superposition of two molecules in the previous orientation except for the inversion of the second molecule through the symmetry centre. Physically, and according to the chemical evidence, this must correspond to a simple random reversal of direction of successive azulene molecules in the crystal. A view of the resulting superposition of two molecules is shown in Fig. 1.

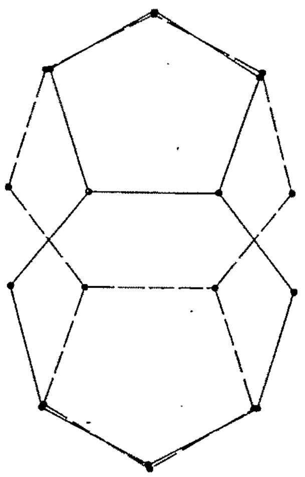

Fig. 1. Superposition of two azulene molecules

On this basis structure factors were calculated, and after some preliminary refinement they showed distinctly better agreement with the observed values than was the case with the non-centrosymmetric structure. Again with the help of Prof. Pepinsky and Dr. Vand eight cycles of least squares refinement were then applied on this new basis, and as a result the overall discrepancy dropped to 13·5 per cent. A comparison of the percentage discrepancies obtained for the two structures is shown in Table 1.

Table 1. PERCENTAGE DISCREPANCIES OBTAINED FOR STRUCTURES) BASED ON THE ALTERNATIVE SPACE GROUPS $P2_1/a$ AND *Pa*

Space group	(*h*0*l*)	(*hk*0)	(0*kl*)	(*hkl*
$P2_1/a$	8·6	8·9	12·9	13·5
Pa	11·5	14·2	20·0	22·4

These figures establish definitely that azulene has a disordered structure as postulated earlier by Günthard[3]. This disorder is of the same type as found in *p*-chlorobromobenzene[4,5] and is also similar to that reported in the case of 2-amino-4-methyl-6-

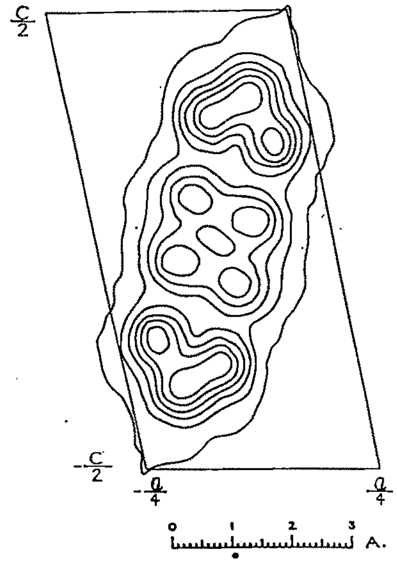

Fig. 2. Azulene. Electron-density projection on (010)

chloropyrimidine[6], though in these cases because of the symmetry of the molecules there are effectively only two atoms involved in the disorder—the chlorine and bromine atoms in the first case, and the chlorine atom and the methyl group in the second case.

An examination of the X-ray photographs showed no trace of additional layer lines and no diffuseness in the spectra, so that the possibility of a fault structure with blocks of the crystal containing molecules properly aligned in one direction and other blocks with molecules properly aligned in the other direction can be excluded. This is also the case with *p*-chlorobromobenzene and 2-amino-4-methyl-6-chloropyrimidine.

An electron-density projection on (010) for the revised structure is shown in Fig. 2. The similarity of this projection of a pair of statistically superimposed molecules to the electron-density projection given in our previous structure[1] is striking and explains the good structure-factor agreement obtained for that structure.

Because of the overlap of atoms the bond-lengths available from this study are of limited accuracy, but the central bond at 1·458 A. appears to be distinctly longer than the other bonds in the molecule. A more complete analysis of this structure will be described elsewhere.

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Presence of 1,2,3,4-Dibenzopyrene in Cigarette Smoke

In an investigation of the neutral fraction of cigarette smoke tar for the presence of carcinogenic hydrocarbons[1], the fluorescence spectra given by various chromatographic fractions were obtained. One of these (spectrum *h*) has been found to be identical with the spectrum given by a sample of pure 1,2,3,4-dibenzopyrene, which has since become available for reference.

The fluorescence spectrum of the compound in cyclohexane consists of a series of fine lines at 462, 470 and 478 mμ, the latter being of lower intensity than the first two. The absorption spectrum of the analytical sample gave all the features of the reference standard[2]. The chromatographic behaviour of both standard and analytical samples on columns of alumina was similar, elution occurring after 3,4-benzopyrene but before 11,12-benzofluoranthene. The latter two compounds, organic solvent solutions of which display a blue–violet fluorescence, occur widely in the combustion products of organic matter. The 1,2,3,4-dibenzopyrene is associated with a light green fluorescence.

The 1,2,3,4-dibenzopyrene was estimated by measurements of the peak height at 331 mμ. 1·6 μgm. was recovered per 100 cigarettes of average weight 1·1 gm., smoked to a stub length of about 1·5 cm. This is of the same order of concentration as that found for 3,4-benzopyrene.

Small quantities of 1,2,3,4-dibenzopyrene have been detected in petrol and the exhaust products of Diesel engines. It has not, however, been detected in a sample of general urban atmospheric soot, in marked contrast to 3,4-benzopyrene, which was found to occur there in a relatively high concentration[3]. Thus, it would appear that the urban-dwelling cigarette smoker has an exposure to 1,2,3,4-dibenzopyrene in a concentration not realized by his non-smoking neighbour.

As a result of preliminary tests, Bachmann *et al.*[4] and Cook and Kennaway[5] have described 1,2,3,4-dibenzopyrene as a carcinogenic agent of considerable potency.

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Radiometric Estimation of Unsaturated Fatty Acids on Chromatograms

A technique is desirable for estimating amounts of fatty acids separated by partition paper chromatography, without necessity for time-consuming elution, and free from inherent errors of strip photometry. Radiometric methods can meet these requirements, and in chromatographic applications have sometimes allowed accurate definition of spot geometry, which in some cases may be quantitatively related to spot content[1].

Kaufman[2] has determined the iodine number of unsaturated fats pipetted on to a paper support, using iodine-131 monobromide in absolute methanol. We have used iodine-131 to develop a method for quantitative estimation of unsaturated fatty acids separated by partition paper chromatography.

The acid mixture is revolved on 15 mm. × 280 mm. Schleicher and Schull 598 *L* paper strips, using a mixture of synthetic hydrocarbons of very low bromine number (0·16) and boiling point 180–190° C., called 'Mepasine' (Polish product, Ciech, Warsaw), as stationary phase, and 90 per cent acetic acid saturated with 'Mepasine' as mobile phase in ascending reversed-phase chromatography under nitrogen. 'Mepasine' is applied to the strips as a 20 per cent solution in freshly distilled ether free of peroxide, followed by evaporation of the ether.

The strip is dried after chromatography at 60° C. for 1 hr. in nitrogen. It is then immersed in 6·5 ml. of a solution of 0·0022 *M* sodium iodide, 0·0044 *M* sodium iodate, and containing about 5 μc./ml. iodine-131 as iodide. The solution is made 0·025 molar in sulphuric acid to liberate iodine. After immersion for 150 min., the strip is removed, and dried overnight at room temperature, during which time excess unbound iodine-131 is given off.

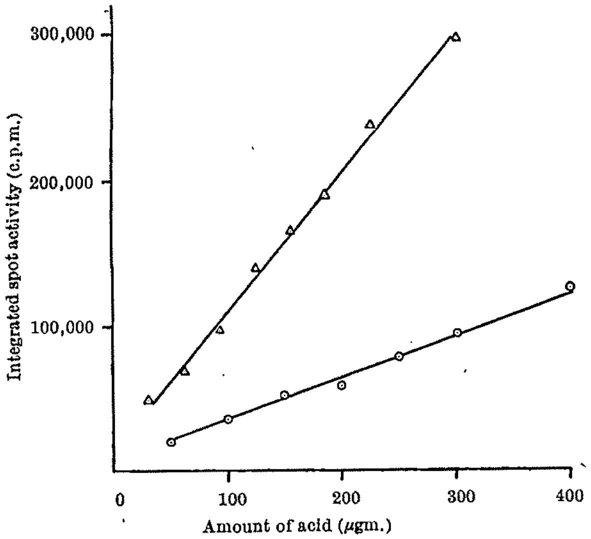

Fig. 1. Relation between integrated spot activity and spot content in chromatograms of oleic (⊙) and linoleic (△) acids iodinated with iodine-131

Distribution of β-activity is determined by drawing the strip in 2-mm. steps under a 2 mm. × 15 mm. slit in a 'Perspex' screen, 4 mm. thick, located under an end-window Geiger–Müller counter with a window thickness of 4 mgm./cm.[2].

Fig. 1 shows the relation between spot content and integrated total spot activity minus background activity of the paper. A satisfactory, reproducible, linear relation, indicating quantitative or reproducibly proportional iodination, is obtained for oleic and linoleic acids. The radiometric technique has also been used to determine spot length or maximum spot activity, in order to relate these to spot content. Maximal spot activity is defined in terms of β-activity counted through a 2 mm. × 15 mm. slit across the point of maximum activity in the spot, and is clearly related to maximum spot thickness. Linear relationships adequate for estimating spot content are also obtained between spot content and spot length, or between logarithm of spot content and maximum spot activity, for chromatograms of oleic and linoleic acids.

To take account of given experimental conditions a calibration line can be set up by chromatography of known amounts of pure oleic or linoleic acids alongside the fatty-acid mixture. Standards for this purpose can be prepared conveniently by chromatography of 200 mgm. of impure acids under nitrogen on paper strips 300 mm. wide, under the conditions described above, followed by elution from the appropriate bands cut from the paper and titration.

Linear relations between spot length and spot content have not so far been reported in paper chromatography of other substances, and no work seems to have been done on correlation of maximum spot thickness with spot content. In fact, apart from less reliable strip-photometry, radiometric estimation would seem to be the only way of measuring maximum spot thickness at present available.

For routine work this estimation procedure can be speeded up by measuring the background activity of the paper immediately before and after the spot, and taking two or three readings around the area of apparent maximum spot density to locate and measure the maximum spot activity, instead of taking the whole radiochromatogram. For this purpose, to locate the region of maximum spot density approximately, and to define the spot area roughly, a conventional visualization technique (such as use of copper ferrocyanide or rhodamine *B*) can be used in conjunction with the radiometric method.

Further studies are in progress to extend this work.

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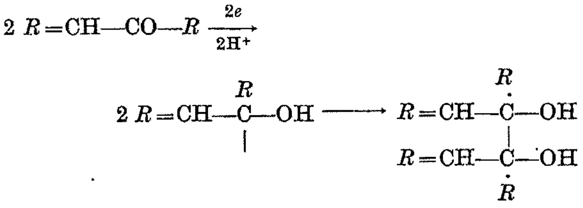
Half-wave Potentials of Aromatic Ketones

The unsaturated aromatic ketones undergo irreversible reduction at the dropping mercury electrode to give different products in acid and in alkaline media respectively. In the acid medium the reduction product is a dimeric alcohol, the formation of which may proceed through an intermediate free radical by the following mechanism:



$$2\,R{=}\mathrm{CH}\text{—}\mathrm{CO}\text{—}R \xrightarrow[2\mathrm{H}^+]{2e}$$

$$2\,R{=}\mathrm{CH}\text{—}\overset{R}{\underset{|}{\mathrm{C}}}\text{—}\mathrm{OH} \longrightarrow \begin{array}{l} R{=}\mathrm{CH}\text{—}\overset{R}{\mathrm{C}}\text{—}\mathrm{OH} \\ \qquad\qquad | \\ R{=}\mathrm{CH}\text{—}\underset{R}{\mathrm{C}}\text{—}\mathrm{OH} \end{array}$$

The half-wave potential ($E_{1/2}$) for the process is therefore associated with the addition of an electron and a proton to the oxygen atom, and according to the view advocated by us[1,2] the half-wave potential may be related to the O-localization energy. In order to test this hypothesis the O-localization energies, $L(-\beta)$, of benzaldehyde, benzophenone and dibenzalacetone have been calculated by the conventional molecular orbital method (taking the Coulomb integral for oxygen as $\alpha_c + 2\beta$ and for the carbon atom attached to oxygen as $\alpha_c + 0{\cdot}1\ \beta$, where α_c is the Coulomb integral for aromatic carbon and β is the resonance integral for the C—C bond) and are given in Table 1 along with the appropriate values for $E_{1/2}$. It is evident from Table 1 that as the localization energy increases, the half-wave potential also increases. In the case of acetophenone and benzalacetone, the presence of an electron-donating methyl group at the α-position with respect to the C=O group will increase the electron density at the bond, and consequently the energy necessary to add an electron to the oxygen atom in acetophenone will be greater than in benzaldehyde. In fact, in the acid region, the half-wave potential of acetophenone is higher than that of the benzaldehyde. The localization energy for acetophenone could be calculated by the molecular orbital method taking into consideration the hyperconjugation effect of the methyl group, but the calculation is so involved that it was not considered worth the trouble.

Table 1. Localization Energy and Half-wave Potentials for Aromatic Ketones

Compound	pH	$E_{1/2}$ (vs. S.C.E.)*	$L(-\beta)$	$E_M(a - a_c/\beta)$
Benzaldehyde	1·3	0·98	2·6900	0·1900
Benzophenone	1·3	0·94	2·5930	0·1450
Dibenzalacetone	1·3	0·90	2·5178	0·0836

* See ref. 4.

The last column of Table 1 gives the energy (E_M) of the first unoccupied molecular orbital, which according to Maccoll[3] should be related to the half-wave potential of the compound concerned. It is evident from Table 1 that Maccoll's suggestion is equally valid for the reduction of these ketones in the acid region.

In the alkaline region the double bond reduced depends on the nature of the compound. Thus benzophenone is reduced to the corresponding alcohol, whereas benzalacetone gives the corresponding saturated ketone. In one case the C=O bond is reduced, while in the other the C=C bond is reduced. These systems, therefore, cannot be compared by the localization method, although Maccoll's method of adding two electrons to the first empty level will still be valid.

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Fluorescent Derivatives obtained by the Reaction of Ethylene Diamine with Epinephrine and Norepinephrine

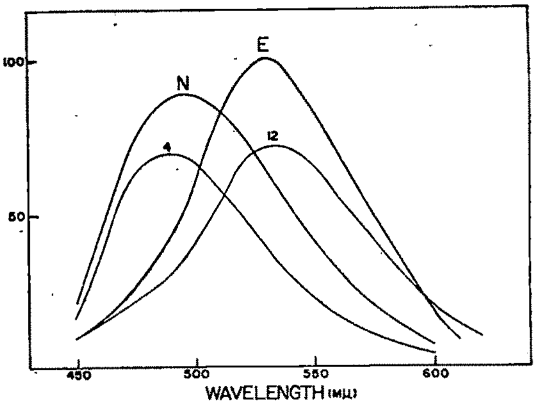

Fig. 2. Fluorescence spectra of *iso*-butanol extract from epinephrine (*E*), norepinephrine (*N*) and of various derivatives obtained after separation with paper chromatography. The numbers correspond to those of chromatogram *A* in Fig. 1. Relative height of peaks is not significant. (Excitation wave-length, 436 mμ)

In the analytical procedure[1-3] for catechol amines based upon their reaction with ethylene diamine, it is commonly assumed that both epinephrine and norepinephrine form a single fluorescent derivative respectively, although Burn and Field[4] have recently supported the existence, for each amine, of at least two fluorescent products. Gray and Young[5], on the other hand, have failed to demonstrate more than one derivative by means of paper chromatography.

Preliminary trials in this laboratory, with circular paper chromatography (using a highly retentive paper such as Schleicher and Schuell No. 576 and an *iso*-butanol/acetic acid/water developing solvent), gave some indication that the fluorescence obtained by the reaction of ethylene diamine on either catechol amine was due to several constituents rather than to a unique 'condensation' derivative. Further attempts to separate these constituents, either by ascending paper chromatography or by paper strip and curtain electrophoresis, were more or less successful until it was discovered that the large excess of ethylene diamine used for the reaction interfered with proper resolution. When electrophoretic separation on paper strips was then attempted on an *iso*-butanol extract obtained from the reaction with epinephrine, nine bands of fluorescent material were visible under optimum conditions (McIlvaine pH 8·0 buffer diluted 1 : 5 with water, 200 V., 20–25 m.amp. for 4 hr.). The same procedure applied to norepinephrine yielded eight distinct bands.

Better resolution was obtained by means of two-dimensional chromatography on paper, if the excess of ethylene diamine was eliminated either from the reaction mixture or its extracts. Development in a first direction with an aqueous phase (butanol-saturated phosphate buffer at pH 6·0) eliminated most of the unchanged epinephrine and the residual ethylene diamine, which both migrated rapidly, as compared with the other constituents of the mixture. A mixture of *n*-butanol/acetic acid (100 : 15) saturated with water was then used for development in the other direction. Fig. 1 illustrates two typical chromatograms obtained from epinephrine and norepinephrine respectively. The identity of various spots with epinephrine

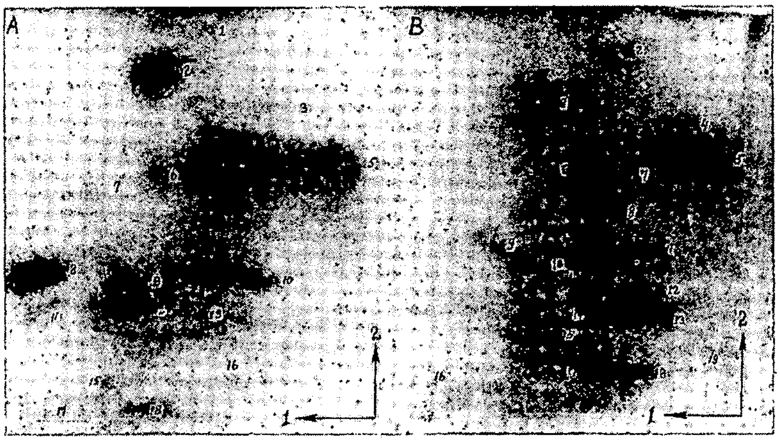

Fig. 1. Two-dimensional chromatograms obtained from epinephrine (*A*) and norepinephrine (*B*), after reaction with ethylene diamine (*iso*butanol extract). Spot Nos. 1, 2, 4, 5, 6, 8, 9, 10, 12 and 16 in chromatogram *A* correspond to radioactive areas obtained from β-^{14}C-DL-epinephrine

derivatives was confirmed by duplicating the procedure with epinephrine labelled with carbon-14. Localization of radioactive areas was obtained by placing the chromatograms in contact with Ilford 'No-Screen' or Kodak 'Blue Brand' medical X-ray films for several weeks.

The spot located at approximately R_F 0·58–0·61 (first dimension) and R_F 0·29–0·35, identified as No. 12 in chromatogram *A* (Fig. 1), gives an intense yellow fluorescence under ultra-violet light and forms one of the major constituents of the reaction mixture. Its fluorescence spectrum is compared in Fig. 2 with those of some secondary products and of the total extractable fluorescence obtained according to the procedure described by Weil-Malherbe and Bone[2]. Fluorescence spectra were obtained with the aid of a Beckman 'Model *B*' spectrophotometer modified by us for that purpose[6].

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A Simple and Rapid Method for the Biological Assay of Glucocorticoids

IT has been well established that adrenocortical steroids have a pronounced effect on carbohydrate metabolism, in particular on the level of liver glycogen. Various methods for the assay of adrenocorticoids have been reported[1,2], based upon the ability of these substances to cause a deposition of glycogen in the livers of adrenalectomized rats and mice. However, all these methods appear to be sufficiently complex and tedious to exclude their use when rapid screening procedures are desired. Van der Vies[3] has described two colorimetric methods for the determination of glycogen in body tissues.

In a series of experiments on mice, by modifying the method of Venning, Kazmin and Bell[2], and employing a modification of one of the methods of van der Vies[3], we have produced a simple, rapid, yet highly sensitive method of assaying the glucocorticoid effect of some adrenal steroids.

Male white mice (13–15 gm.) of the Swiss strain produced by the Agricultural Research Council were used in all experiments. The mice are adrenalectomized under ether anæsthesia and maintained on a cube diet (M.R.C. 41*b*) with normal saline for drinking. On the evening of the first post-operative day food is withdrawn and the mice fasted until the following morning. On the morning of the second post-operative day the mice are divided at random into groups of ten and injected intramuscularly with the steroid or test material. Three hours after treatment the animals are weighed as a group, killed by stretching the necks, and their livers extirpated. The whole livers of all the mice in a group are transferred as quickly as possible into 100 ml. of a 5 per cent solution of trichloracetic acid and homogenized or ground with sand in a mortar. The homogenate is filtered under reduced pressure through a Whatman No. 54 paper. A sample of 2 ml. of the filtrate is taken and added to 2 ml. of 10 *N* solution of potassium hydroxide in a boiling-tube. The solution is heated for one hour in a boiling water-bath and then cooled; 1 ml. of glacial acetic acid and 5 ml. distilled water are added. After mixing, 2 ml. of this solution is slowly added to 4 ml. of freshly prepared anthrone reagent (0·2 per cent anthrone in 95 per cent sulphuric acid) in a boiling-tube which is placed in iced water to prevent excessive heating. The solutions are mixed by lateral shaking and placed in a boiling water-bath for exactly 10 min. for colour development, and cooled with tap-water. The extinction is read within 2 hr. in an absorptiometer at 650 mμ against a blank prepared by submitting 2 ml. trichloracetic acid to the same procedure as that described for the liver homogenate. The glucose standards for the calibration curves are prepared by heating three quantities of 2 ml. trichloracetic acid and 2 ml. potassium hydroxide in a water-bath as described above, then adding 1 ml. glacial acetic acid followed by 0·5-ml., 1·0-ml., or 2·0-ml. samples of a 1 mgm./ml. solution of glucose in distilled water. After the addition of 4·5 ml., 4·0 ml. and 3·0 ml. of distilled water, respectively, the procedure is continued in the usual way.

The result is expressed in terms of mgm. liver glycogen equivalent per 100 gm. mouse body-weight.

Venning and her associates[2] demonstrated that specific quantities of glucose administered together with the steroid provoked a striking increase in liver glycogen deposition, although the increase caused by the same dose of glucose administered alone was not significant. In this present study preliminary experiments have corroborated this finding (Fig. 1). These results indicate that doses of either 10 mgm. or 20 mgm. glucose per mouse, incorporated into the injection solution, greatly increase the response to a given dose of cortisone acetate, without themselves

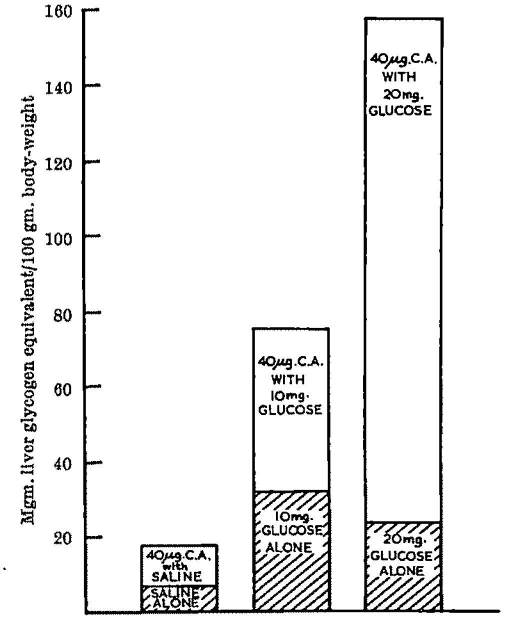

Fig. 1. The effect of glucose, incorporated into the injection solution, on the response produced by a standard dose of cortisone acetate*

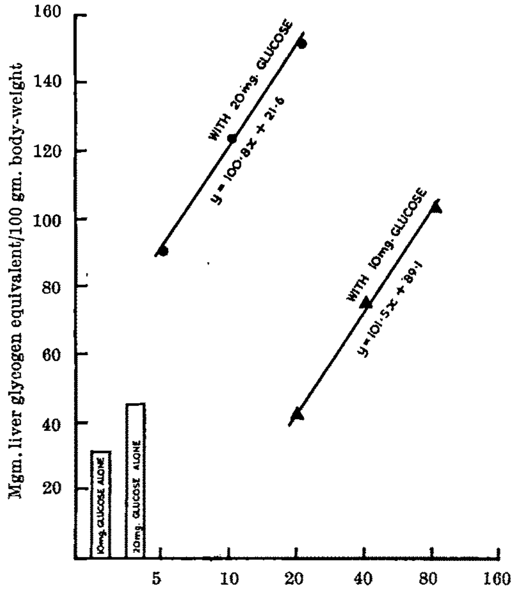

Fig. 2. The effect of glucose, incorporated into the injection solution, in enhancing the sensitivity of the assay method to cortisone acetate

having any pronounced effect on the level of glycogen in the liver. However, further experiments have shown that doses of glucose greater than 20 mgm. per mouse cause deposition of glycogen in the liver. In agreement with the findings of other workers[2] these studies have also shown that there is considerable variation in the liver glycogen response to injected glucose between different strains of mice. Further investigations have shown that the range of sensitivity of the method to adrenal steroids can alter accordingly to the amount of glucose injected with the steroid (Fig. 2). A dose of 10 mgm. glucose injected with the steroid produced a range of sensitivity of 20–80 μgm. of cortisone acetate, whereas with a dose of 20 mgm. the sensitivity was increased to a range of 5–20 μgm. of cortisone acetate.

The assay method has proved to be simple, rapid and highly sensitive. The practice of estimating the glycogen-level of the bulked livers of a group of mice does not enable information to be calculated concerning the scatter in the individual responses within each dosage group. However, it is considered that the method of assay described is well suited to the routine examination of synthesized compounds for glucocorticoid activity.

We should like to express our appreciation to Prof. G. A. H. Buttle, for his helpful advice and interest in this work.

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5-Hydroxytryptamine and Hyperglycæmia

It has been suggested that the hyperglycæmic substance present in the blood of the pancreatico-duodenal vein of animals treated with the growth hormone of the pituitary gland is 5-hydroxytryptamine[1]. This amine may be derived from the enterochromaffin or other cells of the gastrointestinal tract. Yet injections of 5-hydroxytryptamine into normal dogs fail to produce a significant rise in blood sugar, although similar injections into depancreatized animals result in hyperglycæmia. Thus the pancreas may be responsible for the inactivation of 5-hydroxytryptamine.

Recently I have been studying the distribution of 5-hydroxytryptophan decarboxylase, an enzyme forming 5-hydroxytryptamine from 5-hydroxytryptophan, and I was surprised to find that the pancreas possesses a considerable degree of enzyme activity. For example, homogenates of the pancreas of the rat, guinea pig, rabbit, cat and dog all possessed activity, 1 gm. of tissue forming 19–55 μgm. of 5-hydroxytryptamine in 60 min. For comparison, the richest source of the enzyme, namely the kidney, formed 47–188 μgm. of 5-hydroxytryptamine/gm. of tissue. The method of Gaddum and Giarman[2] was followed using 4×10^{-4} *M* substrate, but in place of the choline *p*-tolyl ether I used iproniazid as the inhibitor of monoamine oxidase. When 5-hydroxytryptamine was used as the substrate and iproniazid was omitted from the reaction mixture, it was possible to estimate the monoamine oxidase activity of the homogenates. This showed that 1 gm. of pancreas deaminated 1·2–2·4 μgm. of 5-hydroxytryptamine in 60 min., whereas 1 gm. of kidney inactivated about 8 μgm. of the amine when tested by this method.

The pancreas has not so far been considered as a source of 5-hydroxytryptamine. The present results show that it possesses not only much 5-hydroxytryptophan decarboxylase activity but also monoamine oxidase activity. This latter finding probably explains why the 5-hydroxytryptamine content of the pancreas of the species tested is so low (0·05–0·1 μgm./gm.). It should now be possible to identify the hyperglycæmic substance in the pancreatico-duodenal blood after injections of growth hormone, and to test its action on the blood sugar of animals treated with monoamine oxidase inhibitors such as iproniazid or choline *p*-tolyl ether.

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A Yellow Fluorescent Pigment in Elastin

Mainly due to the pioneer work of Szent-Györgyi[1] it is known that a close relationship may exist between the fluorescence of a certain compound and its activity in energy transfer and thus in metabolism. This suggests that the strong fluorescence of elastin[2], until recently regarded as an inert protein of only structural significance, may be important.

The cause of this fluorescence has not been established. With[3] suggested the presence of firmly bound pigments originating from porphyrin in elastin, and Partridge and Davis[4] found a yellow pigment in their elastin hydrolysates. Labella[5] was the first to postulate a metabolic function for elastin, suggesting that the presence of an unsaturated lipid is necessary to maintain the particular structure of the elastin molecule. The occurrence of a strong fluorescence was not noticed by the latter authors.

I prepared elastin from ligamentum nuchæ of cattle according to Partridge *et al.*[6]. Partial hydrolysis by activated papain followed by dialysis yielded a clear, bright yellow solution with a yellowish-white fluorescence. Paper chromatography (Whatman 1 or 3 *MM* paper, *n*-butanol/ethanol/0·5 *M* ammonia (70 : 10 : 20) (v/v)) showed a bright fluorescent spot with R_F 0·86, but most of the yellow pigment remained bound to polypeptide residues, as was indicated by subsequent paper chromatography after hydrolysis with hydrochloric acid.

Milligram amounts of the pigment were prepared by hydrolysis with hydrochloric acid. 15 gm. of dry elastin powder were hydrolysed with 600 ml. of 6 *N* hydrochloric acid by refluxing for 24 hr., the hydrochloric acid was removed (by evaporation under reduced pressure in an atmosphere of nitrogen) and the yellow pigments adsorbed on charcoal. The pigments were eluted with hot pyridine, the pyridine was removed completely and the dry residue extracted with dry peroxide-free ether. This solution was washed with 2 per cent sodium bicarbonate and then with a 2 per cent sodium hydroxide solution to extract fluorescent impurities which originate from the action of hydrochloric acid on amino-acids. The pigment was purified by large-scale paper chromatography on Whatman 3 *MM* paper.

A number of properties of the pigment have been determined by chromatography in various solvents, spectrophotometry and chemical spot tests[7].

The pigment is insoluble in water and petroleum ether, but soluble in methanol, ether and chloroform. The absorption spectrum (Fig. 1) shows two distinct absorption maxima, almost independent of the *p*H of the solvent. The R_F value (0·85–0·88) is not altered by substituting acetic acid for the ammonia in the solvent, which also shows that the compound has no distinct acidic or basic properties.

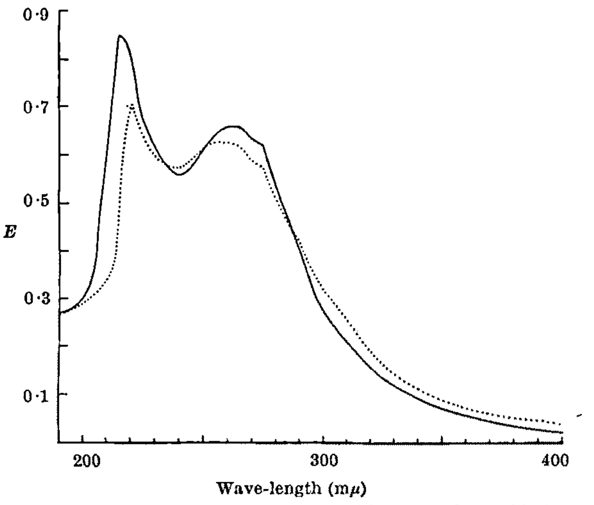

Fig. 1. Absorption spectrum of pigment in 0·01 *N* hydrochloric acid in absolute ethanol (——) and in the same concentration in 0·01 *N* potassium hydroxide in absolute ethanol (- - -)

The presence of the elements carbon, hydrogen and nitrogen was shown, the nitrogen probably being present as a tertiary amine. Oxidation with nitric acid shows the formation of polynitro compounds and the appearance of a carboxylic acid. Spray reagents on paper revealed aromatic hydroxyl groups and a positive Ehrlich diazo reaction. Tests for pyrrole were negative.

Preparation of a larger amount of pigment allows a more exact examination of its properties. These results suggest a structure related to the pyrimidines, purines or pteridines.

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Differential Demonstration of Acetylcholinesterase and Non-specific Cholinesterase in the Adrenal Medulla of the Rat

Using naphthyl acetates as substrates, Coutinho *et al.*[1] demonstrated histochemically that adreno-medullary cells of the rat can be divided into two categories, esterase-positive and esterase-negative. Allen, Eränkö and Hunter[2] confirmed this observation and showed that the regions of those medullary cells which fluoresce in ultra-violet light after fixation in calcium formol and which presumably contain noradrenaline[3] were strongly cholinesterase-positive, while the remaining parenchyma was weakly positive or negative. After studies with some inhibitors they also suggested that two or more types of cholinesterases are involved in the histochemical reactions.

The nature of the adreno-medullary cholinesterases has been further studied by using 62.*C*.47 (1 : 5-*bis*-(4-trimethylammonium-phenyl)pentan-3-one di-iodide), a specific inhibitor of acetylcholinesterase, and tetra-*iso*propylpyrophosphoramide, a specific inhibitor of non-specific cholinesterase[4]. Acetylcholinesterase was demonstrated using Koelle's[5] improved method. Into the prescribed substrate mixture containing acetylthiocholine, however, tetra-*iso*propylpyrophosphoramide was added in a molar concentration of 10^{-6}. For the demonstration of non-specific cholinesterase, acetylthiocholine was replaced by butyrylthiocholine and 62.*C*.47 was used instead of tetra-*iso*propylpyrophosphoramide in a molar concentration of 10^{-5}. Naphthyl acetate was also used as a substrate.

Sections incubated in solutions of acetylthiocholine and tetra-*iso*propylpyrophosphoramide showed a positive reaction in the ganglion cells, the nerve trunks and a network of fine fibres surrounding all parenchymal cell groups. In the fine nerve net, small knobs were strongly positive. After incubation in butyrylthiocholine and 62.*C*.47, ganglion cells and nerve trunks were again strongly stained. On the other hand, the main bulk of the medullary parenchyma was essentially negative except for groups of parenchymal cells forming small islets, which were surrounded by a network of strongly positive fibres. Incubation with butyrylthiocholine or with α-naphthyl acetate produced identical results with or without 62.*C*.47. Eserine and tetra-*iso*propylpyrophosphoramide (10^{-6} *M*) inhibited the medullary reaction with these substrates.

Since the reaction worked equally well with fresh-frozen and with calcium formol-fixed sections, it was possible to register photographically, first the distribution of the calcium formol-induced fluorescence, and then that of the cholinesterases. It was thus proved that the regions of the fluorescent cell groups showed a high, the non-fluorescent parenchyma a low, activity of non-specific cholinesterase.

Non-specific cholinesterase can be demonstrated in a specific way with butyrylthiocholine even without 62.*C*.47. This was done, the section was photographed, incubated with acetylthiocholine and 10^{-6} *M* tetra-*iso*propylpyrophosphoramide to detect acetylcholinesterase, and photographed again. Comparison of the pairs of photographs thus obtained confirms very clearly the different distributions of acetylcholinesterase and the non-specific esterase in a single section. Similar differentiation could not be obtained using di-*iso*propylfluorophosphate, which has commonly been used to inhibit non-specific cholinesterase[5].

Denervation of the adrenals was followed by a total disappearance of acetylcholinesterase from the medulla, except for the cytoplasm of some ganglion cells, but did not affect the distribution of non-specific cholinesterase in the fluorescent parenchyma. Prolonged treatment with nicotine, on the other hand, resulted in an increase in the intensity of the non-specific cholinesterase reaction, and the reaction was more widely spread in the medulla than normally.

These results justify the conclusion that there are in the adrenal medulla of the rat two types of cholinesterases, which behave differently towards different substrates and different inhibitors. Of these the type which is sensitive to 62.*C*.47 and which disappears after denervation is apparently a specific acetylcholinesterase coupled to the mechanism of nervous transmission. The other enzyme, which is sensitive to tetra-*iso*propylpyrophosphoramide, affected by treatment with nicotine and selectively localized in the regions of the parenchymal cells containing noradrenaline, may be connected with the metabolic processes of these parenchymal cells.

Further details of the methods and results will be published elsewhere.

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Agar Electrophoretic Patterns of Red Blood Cell Proteins

IT has been previously reported from this laboratory that both animal (rat)[1,2] and human[3] red blood cell hæmolysates show the presence of minor protein components other than hæmoglobin after electrophoresis in agar gel medium. Because of their possible interaction with hæmoglobin molecules in the red cell and their variation in hæmatological disorders and other pathological conditions, more detailed study of these proteins appeared of interest.

Stern *et al.*[4], in a preliminary study, demonstrated the presence of proteins other than hæmoglobin by moving-boundary electrophoresis. The hæmolysates examined (man, dog and chicken) showed the presence of a small amount of an opalescent, colourless fraction (protein *a*) with anodic mobility (at *p*H 8·6) twice as high as that of oxyhæmoglobin. This protein component was assumed to be derived from the membrane or stroma of the cells. In addition to this component, human and dog hæmolysates were found to contain another colourless component (protein *b*) with a mobility smaller than that of hæmoglobin, while chicken red cell hæmolysate was found to contain a component (protein *c*) with a mobility intermediate between that of hæmoglobin and protein *a*. Hoch[5] reported the occurrence of two components faster than the oxyhæmoglobin in fresh red-cell extracts.

The minor protein patterns observed by the agar electrophoresis technique showed marked difference from the moving boundary patterns obtained by Stern *et al.* and Hoch. At least three minor protein components, in addition to hæmoglobin, are present in human red blood cell hæmolysates, with mobilities lower than that of hæmoglobin, and no fast-moving component (protein *a*) was observed.

The method of separation of these proteins by agar electrophoresis followed the procedure presented previously, except that higher concentration of the hæmolysate was used to reveal the minor protein components, some of which will not be visible at the low concentrations used in previous experiments reported earlier. After electrophoresis, the proteins were stained with amido black 10*B* [6].

Fig. 1 is a typical pattern showing the minor protein components and the hæmoglobin in human red-cell hæmolysate. The red cells were washed six times with 0·9 per cent sodium chloride before hæmolysis.

Hæmolysates from more than twelve samples of human blood examined by this method always gave the same result. Separation of three protein components was, therefore, reproducible. For convenience the protein components are designated RP_1, RP_2 and RP_3 with decreasing order of mobility. RP_1 and RP_2 occur in high concentration compared to RP_3. Occasionally the RP_1 component merged with the hæmoglobin band. The protein components did not give any positive reaction with benzidine reagent, fuchsin sulphite after periodate oxidation or sudan black, thereby showing that they are not hæmoglobins and they do not contain carbohydrate or lipid materials. The electrophoretic behaviour of the protein components (compactness of the bands and the difference between their mobilities and those of serum proteins) indicates that they are the intracellular proteins of the red cell and not serum proteins. A comparative study of the electrophoretic patterns of human serum proteins and hæmolysates obtained on the same plate showed that the mobility of RP_3

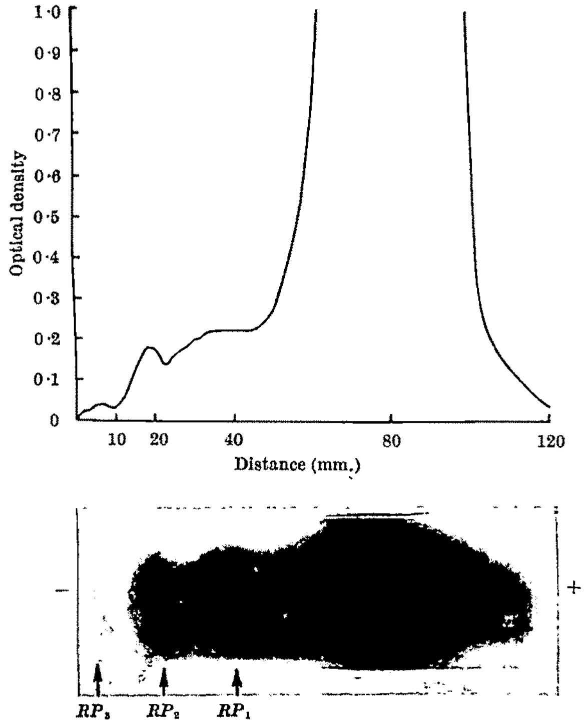

Fig. 1. Agar electrophoretic pattern of human red blood cell proteins. (8·6 *p*H ; 200 V., 8 m.amp., 10 hr. run, 80 μl. of hæmolysate applied on the gel)

approached that of γ-globulin, while RP_1 and RP_2 possessed mobilities between those of γ- and β-globulins of serum. The relative amounts of RP_1, RP_2 and RP_3 as determined from the areas of the peaks obtained by densitometric measurement are approximately 40, 46 and 14 respectively (excluding hæmoglobin). Animal red blood cells (rat and sheep) also contain these proteins to a varying degree. It will be of interest to investigate the variation of these proteins in red blood cells under pathological conditions and their significance in relation to hæmoglobins, and sickling phenomena and allied hæmatological disorders.

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Pre-requisites for Dextran Production by *Streptococcus bovis*

In a recent paper[1] we showed that many strains of *Streptococcus bovis* of rumen origin gave good yields of an unbranched dextran when incubated anaerobically for one day at 38° C. in a liquid sucrose medium. An essential condition for these yields of dextran was either incubation in a 100 per cent carbon dioxide atmosphere or the incorporation of solid calcium carbonate or 0·01 *M* bicarbonate in the medium. The latter was well buffered with 0·05 *M* phosphate and also contained 0·5 per cent yeast extract and 1·1 per cent casitone, or an equivalent peptone as sources of organic nitrogen, and growth factors. In the absence of carbon dioxide, cell yields were almost as good as in its presence and, though a normal lactic acid fermentation took place, little or no dextran was produced. No detailed study of the effect of buffer strength and composition on dextran yields nor any attempt to simplify the medium was made at the time.

We now find that :

(*a*) Adequate buffering of the medium is a prerequisite for high dextran yields. Reducing the phosphate to a level (0·01 *M*) which was still adequate for good growth and fermentation, almost completely stopped production of dextran even though carbon dioxide was supplied. As found by Whiteside-Carlson and Carlson[2] with *Leuconostoc*, phosphate could, with advantage, be replaced by acetate, since the latter can be used at a much higher concentration than phosphate (up to 0·25 *M*) without affecting growth. The effect of acetate concentration (in the presence of bicarbonate ion) on the conversion of sucrose to dextran and free fructose by *S. bovis* is shown in Table 1. High yields of dextran and of free fructose can be obtained after incubation for only 24 hr. at 38° C. without any external neutralization of the culture. Acetate can be replaced by propionate or butyrate or even by salts of organic acids of much lower pK_a values, such as lactic and formic acids. In these later cases the dextran yield is lower than with acetate of equivalent concentration.

(*b*) A carbohydrate and protein-free basal medium suitable for dextran production was devised by replacing the casitone and yeast extract by acid-hydrolysed casein and a mixture of B vitamins and growth substances similar to those used for *Leuconostoc* by Whiteside-Carlson and Carlson[4]. According to Ford, Perry and Briggs[5], *S. bovis* requires no B vitamins for anaerobic growth ; nevertheless we have clear evidence that pantothenic acid is absolutely necessary for the anaerobic production of dextran. Unlike *Leuconostoc*, however, *S. bovis* still requires carbon dioxide and a buffer in conjunction with this simplified medium for production of dextran to occur.

(*c*) Carbon dioxide gas in solution and not the bicarbonate ion is the first essential requirement for production of dextran. This follows from the following observations relating to sucrose cultures of *S. bovis* containing the correct phosphate *and bicarbonate*

Table 1. Effect of Acetate Buffer on the Conversion of Sucrose to Dextran, Fructose and Leucrose by *S. bovis* (Strain 1)

Acetate (*M*)	Dextran (percentage conversion of available glucose)	Free fructose (percentage of available fructose)	Leucrose (percentage of available sucrose)	Residual sucrose (by paper chromatography)
(1) Medium 0·5 per cent 'Bacto' yeast extract, 1·4 per cent 'Bacto'-tryptose, 8·5 per cent (w/v) sucrose and 0·004 *M* potassium carbonate (sterilized separately) ; 24-hr. incubation at 38° C.				
0·0	0·0	—	—	+ + + + +
0·036	6·2	—	—	+ + + + +
0·055	14·5	—	—	+ + + +
0·073	26·8	—	—	+ + +
0·091	36·0	—	+	+ +
0·110	73·8	—	+ +	+
0·128	87·0	60·0	6·0	0
0·147	89·0	71·7	7·3	0
0·184	87·0	87·0	12·2	0
(2) Medium as for (1) above except that sucrose 12 per cent (w/v) ; incubated 48 hr. at 38° C.				
0·184	85·2	67·5	10·1	0
0·256	79·6	63·8	8·1	0

concentrations for production of dextran, through which a slow, oxygen-free, stream of hydrogen was bubbled at 38° C. for 24 hr. (1) The organism would not grow at all if the hydrogen stream was free from carbon dioxide. (2) There was fair growth without formation of dextran if the hydrogen was first bubbled through 0·5 per cent sodium bicarbonate solution at room temperature to supply a trace of carbon dioxide, since bicarbonate solutions tend to revert to carbonate with loss of carbon dioxide even at room temperature. (3) There was good growth and good formation of dextran with conditions exactly similar to (2), except that the hydrogen was bubbled through saturated (10 per cent) sodium bicarbonate solution. We conclude that the concentration of carbon dioxide in solution needed for production of dextran is much higher than that essential for growth. The bicarbonate may function merely as a source of carbon dioxide at low *p*H values brought about by production of lactic acid rather than as the ion itself. In contrast, *Leuconostoc mesenteroides* still grew and produced dextran even when a stream of hydrogen free from both oxygen and carbon dioxide was bubbled through the sucrose medium at 28° C.

Not all rumen strains of *S. bovis* behave similarly, but even those strains that do not appear to have a definite need for carbon dioxide for slight production of dextran nevertheless require good buffering of the medium for production of dextran to occur. Temperature is a factor of importance in certain cases. We have one strain which appears to need carbon dioxide for formation of dextran at 38° but not at 28° C. Other strains behave similarly at both temperatures, except that growth is necessarily slower at 28° C. The organism will also grow at 47° C. in the presence of bicarbonate and high phosphate buffering, but no dextran is produced.

In contrast to *Leuconostoc*, the dextran formed at 28° C. is also unbranched. Addition of 0·008 *M* magnesium ion to the acetate-buffered medium, although resulting in only a trace of precipitate on autoclaving, did not produce branching in the *S. bovis* dextran at either 28° or 38° C. (cf. ref. 6).

As with *Leuconostoc*, good yields of dextran can be obtained only in sucrose media. A point of considerable importance, however, is that the specific soluble enzyme concerned (which appears to act as a dextransucrase; cf. ref. 7) is produced quite prolifically, by *S. bovis* at least, in a glucose liquid medium (particularly if it contains a mere trace of sucrose) as well as in a sucrose liquid medium. The enzyme was produced even when the culture used for inoculation had been carried through five successive tubes of glucose liquid medium and hence contained no trace of sucrose or apparently of dextran. The dextransucrase of *S. bovis* therefore appears to be constitutive rather than adaptive. Karström[8] long ago asserted that the *Leuconostoc* (*Betacoccus arabinosaceous*) enzyme system for dealing with sucrose was constitutive and not adaptive. However, he grew the organism at 37° C. and carried out his experiments with the washed cells in non-nutrient media at 45° C. It is unlikely, therefore, that he was studying *Leuconostoc* dextransucrase, which is mostly secreted extracellularly and is unstable at these temperatures[7]. Actually he had previously stated[9] that the sucrase of *Leuconostoc* is a glucosucrase; no mention was made of dextran as a product. The question of the adaptive or constitutive nature of *Leuconostoc* dextransucrase appears to be worth re-investigating.

The essential difference between *Leuconostoc* and *S. bovis* is that the former produces its own carbon dioxide (presumably within the cell) and acetate by sugar fermentation, whereas the latter produces only lactate—not a good buffer for dextran formation (see above)—without carbon dioxide. These deficiencies (namely, carbon dioxide and acetate or equivalent buffer) have apparently to be made good in the nutrient medium itself if dextran formation is to occur. So far as the production of the unbranched dextran is concerned, there is no need at this stage to postulate different mechanisms for *Leuconostoc* on one hand and *S. bovis* on the other.

This work on enzymes will be reported in full elsewhere by one of us (R. W. B.).

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Content of Citrulline and Other Amino-Acids in a Protein of Hair Follicles

CITRULLINE has been shown to occur in the fibrous protein of the inner root sheaths of hair follicles[1]. This appears to be the first recorded occurrence of citrulline in an animal protein, although Smith and Young[2] described its presence in the protein of the red alga, *Chondrus crispus*.

In view of the unexpected occurrence of citrulline, it was of interest to investigate the quantitative composition of the protein of the inner root sheath and to compare it with the composition of the hair with which it is associated in the follicle.

Samples of inner root sheaths, hair roots and of the hairs themselves were prepared from vibrissa follicles of the rat[1]. They were dried in vacuum at 60° C. over phosphorus pentoxide and hydrolysed in sealed tubes for 10 hr. at 105° C. with constant-boiling hydrochloric acid, and subjected to quantitative amino-acid analysis by the ion-exchange chromatographic technique of Moore and Stein[3,4] as modified in this laboratory[5].

Because of the difficulty of obtaining sufficient inner root sheath and hair root material only single analyses were possible and the total nitrogen contents were not estimated. The analytical results could be expressed only as per cent dry weight (Table 1).

Control runs of authentic samples of *l*-citrulline and *l*-ornithine confirmed the identity of the peaks of these two amino-acids with those obtained in the analytical runs.

The analytical figure for citrulline confirms the earlier evidence that this amino-acid is a major component of the protein of the inner root sheath. However, the value reported is probably low because some of the citrulline is destroyed during hydrolysis

Table 1. AMINO-ACID COMPOSITION OF HYDROLYSATES OF HAIRS, HAIR ROOTS AND INNER ROOT SHEATHS FROM VIBRISSA FOLLICLES OF THE RAT

Per cent by weight of sample dried at 60° C. over phosphorus pentoxide

Amino-acid	Hair	Hair roots	Inner root sheath
Alanine	3·5	3·2	3·1
Amide	1·2	1·2	0·4
Arginine	7·8	7·7	5·1
Aspartic	5·8	6·1	7·1
Cystine	13·7	7·4	1·0
Glutamic	11·6	11·4	>18·8*
Glycine	5·1	4·2	2·9
Histidine	1·3	1·4	1·0
iso-Leucine	1·9	2·0	1·6
Leucine	5·5	6·0	7·1
Lysine	3·1	3·2	2·8†
Methionine	—	—	0·1
Phenylalanine	2·7	3·2	2·7
Serine	8·6	6·7	3·9
Threonine	4·6	3·9	2·4
Tyrosine	4·4	4·1	2·1
Valine	3·1	2·9	1·8
Citrulline	—	—	6·1
	83·9‡	74·6‡	70·0‡

* This must be regarded as a minimum figure since the optical density exceeded the limit for accurate reading by the equipment.

† Including ornithine produced from citrulline breakdown.

‡ The recoveries are all low. The analyses do not include tryptophan and proline, and have not been corrected for material not containing protein, such as pigment, nucleic acids, lipids and carbohydrates which are present to an unknown extent.

with the production of ornithine[1], a fact overlooked by Smith and Young, who used longer hydrolysis times in their analysis of *C. crispus*. It was unfortunate that in the present analysis ornithine was not resolved from lysine, and hence the citrulline and lysine contents could not be corrected. The low amide and small lysine plus ornithine figures suggest that this correction is not large.

Comparison of the analytical results shows that the fibrous protein of the sheath contains very little cystine, although methionine is present in greater amount than in hair. Of interest are the low arginine content and the extraordinarily high glutamic acid concentration in comparison with the values for hair, aspartic and glutamic acids together constituting more than 26 per cent of the protein. The low amide content implies that few carboxyl side-chains are amidated. Despite the lack of disulphide bonds compared with hair keratin, the protein of the sheath is not dispersed at alkaline *p*H values or by concentrated urea solutions[1]. If secondary forces are held responsible for this stability, these might be found in the increased possibilities for the formation of strong salt links and hydrogen bonds due to the high concentration of polar side-chains and to citrulline, which itself is a substituted urea.

Although the significance of citrulline in follicle metabolism is unexplained, it has been suggested[1] that the protein of the sheath provides ammonia to the growing hair for amidation of the side-chain carboxyl groups. Thus with the appropriate enzyme system present in the follicle, some arginine side-chains could be de-imidated to citrulline and ammonia. An enzyme system of this type has been described in extracts from crayfish muscle[6]. The amino-acid composition of the protein, in particular the low arginine and amide content, despite a high concentration of dicarboxylic amino-acids, and the high content of citrulline are in accord with this suggestion.

Comparison of the composition of hair roots with that of hair (Table 1) shows that the amide contents are similar, and so also are the amino-acid contents, excepting cystine, which is considerably lower in hair roots. This is in accord with the general view that the final cystine content of hair is established at a late stage in keratinization.

The technical assistance of Miss C. Potter and Miss M. T. McShane is gratefully acknowledged.

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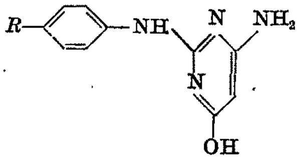
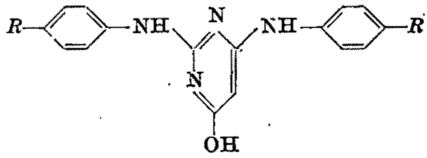
Arylaminopyrimidines as Growth-Inhibitors of *Streptococcus faecalis* and *Lactobacillus arabinosus*

IT has been found by Hitchings *et al.*[1] that 2 : 4-diamino-6-alkylpyrimidines which have bulky substituents (for example, phenyl) at C_5 are strong folic acid antagonists, some of which have marked antimalarial[2] and antileukæmic properties[3]. Furthermore, Curd, Rose and their co-workers had shown previously that many 6-alkylpyrimidines having substituted amino-groups at C_2 and C_4 were active as antimalarials[4].

In continuation of our studies of pyrimidines of potential chemotherapeutic interest, we have prepared several 2-arylamino-4-amino- and 2 : 4-diarylamino - 6 - hydroxypyrimidines (types I and II respectively) (methods of synthesis will be described elsewhere).


(I)


(II)

As shown in Table 1, these substances, particularly the di-arylamino compounds (II), caused marked inhibition of growth of *Streptococcus faecalis* and *Lactobacillus arabinosus*. However, these compounds differ from the parent member of the series, namely,

Table 1. INHIBITION OF *S. faecalis* and *L. arabinosus* BY ARYLAMINO-PYRIMIDINES

Compound	*S. faecalis**‡ Conc. (μgm./ml.) for 50 per cent growth inhibition	*L. arabinosus*†‡ Conc. (μgm./ml.) for 50 per cent growth inhibition
2:4-Diamino-6-hydroxy-pyrimidine	90	220
(I ; R = H)	40	46
(I ; R = CH_3)	30	39
(I ; R = Cl)	12·5	17
(II ; R = H)	8·0	11
(II ; R = CH_3)	4·5	6·2
(II ; R = Cl)	0·8	1·0

* Medium contains pteroylglutamic acid (1 mμgm./ml.) but no purine or pyrimidine metabolites. All other essential nutrients are included (ref. 5).

† Medium contains 20 μgm./ml. each of adenine, guanine, xanthine and uracil but no pteroylglutamic acid (ref. 5).

‡ Growth measured turbidimetrically after 20 hr. at 37° C.

2 : 4-diamino-6-hydroxypyrimidine, and from most other 2 : 4-diaminopyrimidines in that the growth inhibition of *S. faecalis* which they cause is not reversed by the presence of folic acid.

The effects of 2 : 4-diarylamino-6-hydroxypyrimidines on various forms of parasitic growth are now being examined.

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Effect of Monovalent Cations on Type Specificity Transformation in Pneumococci

FOR investigating the mechanism of bacterial transformation we have chosen as the experimental model the transformation of the *R* form of *Diplococcus pneumoniae* type II into the mucous form of *D. pneumoniae* type III, by means of crude extracts of deoxyribonucleic acid, isolated from the mucous form of *D. pneumoniae* type III. Systematic study was hampered by considerable variability in the results and by the low incidence of transformation in the control tubes.

Alexander *et al.*[1], working with *H. influenzae*, found that susceptible cells emerged at the end of the logarithmic period and at the beginning of the stationary phase of the growth-cycle when the density of the cell population was 2 to 4 × 10^8 cells per ml. The appearance of sensitive cells was lowest during the early logarithmic phase. Another important factor influencing the number of cells capable of transformation is the concentration of deoxyribonucleic acid (up to 10^{-1} μgm. per ml.). In practice, when all the above factors are present, only about 1 per cent of the *Haemophilus* recipient population undergoes transformation. In the case of pneumococci[2], 0·2–5 per cent of the exposed population was transformed.

Serum factors, which are necessary in the transformation of types of pneumococci, have been studied in detail[3-6].

Fox[7], without giving any particular details, describes the effect of calcium ions on the increase in the number of transformed cells during transformation of resistance in pneumococci.

In our experiments we were concerned mainly with the problem of how to eliminate variability of the transformation results with the *R* strain in question, with the question of the causes of this variability and with the possibility of increasing the number of *R* cells capable of transformation.

The experiments were carried out with an *R* strain of *D. pneumoniae* type II, obtained from the mucous form of *D. pneumoniae* type II in our laboratory by Griffith's method[8]. The crude extracts of deoxyribonucleic acid were obtained from young 4–6 hr. plate cultures of a strain of *D. pneumoniae* type III, by McCarty and Avery's method[9], using five- or six-fold deproteinization, but without specially removing the polysaccharides and ribonucleic acid. Ultra-violet absorption curves showed maxima in the region of 2580 A. and minima in the region of 2300 A.

Using as transformation method the experimental procedure of Avery *et al.*[3] it was found that the presence of salts with monovalent cations (dipotassium hydrogen phosphate, disodium hydrogen phosphate, potassium chloride, sodium chloride and to a lesser degree ammonium chloride and ammonium sulphate) in the classic neopeptone anti-*R* serum (10 per cent) medium[3], in concentrations of about 5 × 10^{-2} *M* to 10^{-1} *M* in the case of phosphates, and of about 10^{-1} *M* to 3 × 10^{-1} *M* in the case of chlorides, helped in the complete elimination of chance results in transformation of the *R* strain into the mucous form of

Table 1. OPTIMAL CONCENTRATION OF POTASSIUM AND SODIUM SALTS IN TRANSFORMATION OF TYPE SPECIFICITY IN THE STRAIN PMSII

Molarity (*M*)	Neopeptone broth											
	K_2HPO_4						$Na_2HPO_4.12H_2O$					
	inoculum 2 hr.			inoculum 4½ hr.			inoculum 2 hr.			inoculum 4½ hr.		
	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48
5×10^{-3}	000	000	000	000	000	000	000	000	000	000	000	000
10^{-2}	000	000	000	000	000	000	000	000	000	000	000	00+
3×10^{-2}	000	000	000	000	000	000	00+	00+	00+	+++	+++	+++
5×10^{-2}	000	000	+00	0++	0++	+++	0++	0++	+++	+++	+++	+++
$6{\cdot}72\times10^{-2}$	000	00+	+++	+++	+++	+++	0+0	0+0	0++	+++	+++	+++
10^{-1}	+++	+++	+++	+++	+++	+++	+00	+00	+++	+++	+++	+++
	KCl						NaCl					
Molarity (*M*)	inoculum 2 hr.			inoculum 4½ hr.			inoculum 2 hr.			inoculum 4½ hr.		
	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48	16	20 (hr.)	48
$1{\cdot}5\times10^{-2}$	000	000	000	000	000	000	000	000	000	000	000	000
3×10^{-2}	000	000	000	000	000	000	000	000	000	000	000	000
9×10^{-2}	000	000	000	000	000	000	000	000	000	000	000	000
$1{\cdot}5\times10^{-1}$	+00	+00	+00	+++	+++	+++	000	000	000	+00	+00	+00
2×10^{-1}	+00	+00	+0+	+++	+++	+++	000	0++	0++	+++	+++	+++
3×10^{-1}	000	000	+++	+++	+++	+++	+00	+00	+++	+++	+++	+++

Results in three control series, in which the results were read off after 16, 20 and 48 hr. growth in the liquid medium by subculturing at the indicated time on to glucose blood agar plates twice from each test-tube. The macroscopic identification was confirmed by agglutination with the homologous immune serum. 0, No transformation found. +, Transformation positive.

D. pneumoniae type III. Neither the height of the agglutinating titre nor the sodium or potassium content of the anti-*R* sera used had any effect in the results given in Table 1. Transformation was not promoted by calcium chloride. In the presence of lithium and magnesium salts (probably activating deoxyribonuclease) and of cobalt, the medium was sterile.

It was verified experimentally that neither the phosphate buffer nor the quality of the anions was important, and the active part in successful transformation was played by the monovalent cations. Table 1, in which the control, that is, the plain neopeptone broth, shows negative results, gives the results of experiments with a 2- and a 4½-hour inoculum of the *R* strain, containing 220 and 1,330 cells respectively per ml. of the medium. Transformation of the *R* strain to the mucous form of pneumococcus type III commences, under the given conditions, at a concentration of 3×10^{-2} *M* for disodium hydrogen phosphate and 5×10^{-2} *M* for dipotassium hydrogen phosphate. In the presence of potassium chloride and sodium chloride, transformation commences at a concentration of about $1 \cdot 5 \times 10^{-1}$ *M*.

If transformation is observed throughout growth of the culture in the transformation system, the cells of an *R* culture can be successfully transformed in the presence of the above salts, from the commencement of the growth-cycle to the stationary phase. A young *R* culture requires a somewhat higher concentration of salts than an older culture to give uniform transformation results (Table 1).

It is possible that the part played by the above ions is related to the permeability of the cell membrane to the large deoxyribonucleic molecule, although they may act on the deoxyribonucleic acid molecule itself. The cell appears to become more permeable with age, when the outer membrane loses its vitality in the transition from Gram-positivity to Gram-lability, at the end of the logarithmic phase of the growth-cycle and at the commencement of the stationary phase. Gram-labile cells from the primary culture are also found in a newly inoculated medium at the onset of growth. This would provide an explanation of the finding[1] that transformation can be detected better in cells which have been growing from zero to two hours than later, during the active phase of the growth-cycle. At the end of the logarithmic phase the cells form large Gram-labile groupings. These are probably the same groups of susceptible cells described by Hotchkiss[2] which successively develop and disappear as the culture grows, remain capable of transformation for about 15 min. and then lose this property.

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Applications of Erythrocyte Stromata Powder

BLOOD displaying positive serological reaction for syphilis and erythrocytes of blood stored for more than 21 days are usually discarded in blood banks. The erythrocytes of such blood samples were utilized for the preparation of erythrocyte powder. They were washed with saline and hæmolysed with distilled water. The stromata were then washed three times with distilled water cooled to 6° C. Thereafter, the stromata sediment was lyophilized and pulverized in a mortar. The drying could also be carried out at 37° C., the stromata being spread in a thin layer; but the lyophilized preparation was more active. About 1,500 mgm. of fine, pink powder was obtained from 200 ml. of packed red cells. The powder could be stored at 4° C. for at least two months without any appreciable loss of activity. Before use, the requisite amount of the powder was weighed out and washed twice with saline, care being taken to prepare a suspension free from lumps. In this way the powder was cleared of almost all remaining hæmoglobin.

Absorption of antibodies. The erythrocyte powder was successfully used for the absorption of anti-A and anti-B antibodies from test sera of human origin (anti-Rh, anti-Duffy, anti-Kell, etc.). 10–20 mgm. of powder were used for the absorption of 1 ml. of serum. First, a small amount of serum was added to the washed powder sediment, and a diffuse suspension was prepared by vigorous stirring with a glass rod; then the remaining volume of serum was added. The tubes were kept for 2–3 hr. at room temperature, being frequently shaken. Thereafter, the tubes were centrifuged and the serum withdrawn. The absorption performed in this way was almost always complete, and it had to be repeated only in exceptional cases. The absorption of anti-A and/or anti-B antibodies from anti-D serum could be performed not only with Rh-negative but also with Rh-positive erythrocyte powder heated after washing (as a moist sediment) for 10 min. at 56° C.

Absorption of anti-human hetero-agglutinins from rabbit anti-globulin serum was performed by the same technique, the powder of A erythrocytes being used preferably.

For the absorption of anti-D antibodies, 50 mgm. of Rh_0-positive powder per 1 ml. of serum was used. The absorption required 2 hr. at 37° C. Repeated absorptions were frequently required for complete exhaustion of antibodies.

Preparation of 'pure' antibodies. The elution of blood-group antibodies from the red cells has been practised since 1925 [1], but the methods used did not yield 'pure' antibodies in a high titre or in a solution free of ballast proteins. Some progress was made by the application of stromata[2,3].

50–200 mgm. of powder was sensitized with 10–100 ml. of serum. Sensitization with anti-A and anti-B antibodies occurred over a period of 2 hr. at room temperature, and, with anti-D, 2 hr. at 37° C. The sensitized powder was washed three times with saline and suspended in saline or AB serum. About one drop of saline or serum was added per 4 mgm. of powder. The tubes were shaken for 5–7 min. in a water-bath at 56° C., and centrifuged in a 500-ml. flask filled with water warmed to 56° C. The eluate was then withdrawn. The saline eluates were water-clear and contained only about 10 mgm. per cent proteins. The titre of the anti-A and anti-B antibody preparations was up to 1,000.

The anti-D antibody eluate obtained in AB serum had all the properties of an incomplete anti-D serum, titres up to 1 : 2,000 being obtained in colloidal medium. In this way, an anti-D serum group O could be 'changed' into an anti-D serum group AB.

The anti-D antibody eluate obtained in saline did not agglutinate Rh_0-positive cells, but it sensitized Rh_0-positive red cells up to a dilution of 1 : 100 for the action of Coombs serum. Washing the sensitized cells could be omitted without any influence on the reaction. The indirect Coombs test could also be performed by adding saline suspension of Rh_0-positive cells to the mixture of Coombs serum with saline eluate of anti-D. This phenomenon can be explained by the lack of normal globulins in the saline eluate. This observation may possibly be of practical importance for the simplification of the indirect Coombs technique.

Complement fixation test. All test components were added in 0·25-ml. volumes; inactivated serum at 1 : 5 dilution, erythrocyte powder in suspension containing 1–5 mgm./ml. Fixation and incubation were performed at 37° C. Out of forty-three normal sera tested, only five gave positive reactions due to anti-A and/or anti-B antibodies. Three sera from women belonging to group O, who gave birth to infants with hæmolytic anæmia due to ABO incompatibility, were also tested. Two of these sera, with high titre of anti-A and anti-B respectively, gave a strongly positive reaction with A and B erythrocyte powder respectively. The third serum, with a high titre of anti-A, gave only a doubtful reaction.

Immunization of rabbits. A suspension containing 20 mgm. of washed powder injected daily intravenously into rabbits produced no morbid symptoms. Very large amounts of powder could be given subcutaneously or intramuscularly without doing any harm. The application of this method for MN immunization is under investigation.

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Production of High-Titre Diphtheria Toxin in Baffled Shake Flasks

SUCCESSFUL production of high-titre diphtheria toxin has already been described[1], involving aluminium tanks containing 10 or 50 l. of medium. The inoculated medium was stirred at 1,400 r.p.m. so that a vortex was produced, and under these conditions high-titre toxin was obtained in 48 hr. The inocula for the tanks were produced in shake flasks[2] which gave relatively poor results after 48 hr. shaking, and which could not in any way be compared with tanks. Thus no simple method existed which would give high-titre toxin in 48 hr. and which could be used on a scale small enough to allow the easy handling of large numbers of cultures in the laboratory. It was felt that some improvement might be expected if the aeration of the shake flasks was improved, and this led to the use of baffled shake flasks[3]. In the present work 1-l. Erlenmeyer flasks were used, into which single glass baffles (approximate dimensions, 50 mm. high, 25 mm. wide and 1 mm. thick) were fused. On a rotary shaker (140 r.p.m., ½ in. radius) these gave an oxygen uptake at the start of the shaking period of 120 ml. oxygen/100 ml./hr. as measured by the sulphite oxidation technique[4]. This compared with 30–40 ml. oxygen/100 ml./hr. for an unbaffled flask under the same conditions, and the difference was due entirely to the surface of the medium being continuously broken up on the baffle. When no baffle was present the surface of the medium as it swirled around in the flask remained unbroken and no air bubbles were incorporated into the liquid.

For studies on toxin production, the flasks, plugged with cotton wool, and containing 100 ml. medium (either a tryptic digest medium based on that described by Linggood and Fenton[2] or a papain digest medium based on that of Ramon *et al.*[5]) were inoculated with 1 ml. of a 48-hr. culture of a Park-Williams No. 8 strain of *Corynebacterium diphtheriae* previously grown in an unbaffled shake flask. The flasks were placed on the shaker, which was in an incubator room at 35–36° C., and the toxin production was estimated 48 hr. later. A comparison of results from baffled and unbaffled flasks and tank cultures is given in Table 1.

Table 1. *Lf*/ML. VALUES OF FILTRATES OF *C. diphtheriae* GROWN FOR 48 HR. IN SUBMERGED CULTURE

Medium		Unbaffled flasks (average of 3 × 100 ml. cultures)	Baffled flasks (average of 3 × 100 ml. cultures)	Aluminium tanks (average of 4 × 60 l. tanks and 3 × 10 l. tanks)
Papain digest	*BP* 489	100	260	195
	BP 490	30	130	250
	BP 491	—	260	265
	BP 494	80	160	165
	BP 508	180	190	215
	BP 530	—	250	285
	BP 535	95	165	305
Tryptic digest	*P* 1,457	—	235	210
	P 1,458	—	240	195

A big improvement is seen in the toxin titres produced on most batches of media when baffled flasks are compared with unbaffled ones, and it is clear that the new method is often comparable with tank culture. With some batches of media (for example, *BP* 508), however, no advantage of baffled over unbaffled flasks was found, and further, when baffled flasks are compared with tanks, some media give much better results in the tanks (*BP* 535) and some much worse (*BP* 489). Thus the conditions under which toxin is produced in the two systems do not seem to be identical and conclusions drawn from the results produced in one method must be applied with caution to the other. A possible explanation of the differences lies in the different methods used for aerating the cultures. The oxygen uptake of the tank system is relatively low, being about 40 ml. oxygen/100 ml./hr., but since air is flowing continuously over the vortex this value should remain fairly constant. With baffled flasks the initial uptake of oxygen is high, but as the oxygen in the flask is used up it is replaced by air. Thus the oxygen available and the rate of uptake of oxygen diminish, and so the growing organism may be subjected to quite different sets of conditions in the two methods. This work suggests some relation between respiration and production of toxin in the organism, the exact nature of which is

Table 2. EFFECT OF DETERGENTS ON TOXIN TITRES PRODUCED IN BAFFLED SHAKE FLASKS

Medium	Detergent added	*Lf*/ml. (average of 3 × 100 ml. cultures)
BP 505	None	105
	0·1 per cent sodium stearate	265
BP 508	None	190
	0·05 per cent sodium stearate	220
	0·01 per cent 'Calsolene'	250
BP 512	None	195
	0·02 per cent 'Tween 80'	250

obscure, and it may be that optimum conditions vary for each batch of medium.

To illustrate the difference between flasks and tanks, the effect of detergents on production of toxin in baffled shake flasks is shown in Table 2. As can be seen, the results were sometimes quite dramatic, increases of 50–150 *Lf*/ml. being achieved. In view of this, detergents were added to tank cultures, but in that case they were without effect. The reason for this lack of conformity is not clear. It is known that stirring at 1,400 r.p.m. produces very much more foam in the medium than is ever produced in baffled flasks, and it seems possible that the detergent acts by forming a layer of foam in the baffled flask, thus slightly reducing the uptake of oxygen. This would imply that it is possible to over-aerate cultures of *C. diphtheriae* when high-titre toxin is being aimed at, and further work along this line is in progress.

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Dependence of Bone Marrow Cells on the Liver for Purine Supply

IT is well known that higher organisms can utilize the carbon atom of formate molecules for the synthesis of purines, as indeed can liver tissue *in vitro*. However, in rabbit and human bone marrows and in Ehrlich ascites cells of the mouse, formate-^{14}C was found to be utilized very inefficiently for *de novo* synthesis of purines *in vitro*, but very efficiently for labelling thymine in deoxyribonucleic acid[1–3]. As liver extracts restore the ability of these cells to synthesize purines *in vitro*[4], it was suggested that, *in vivo*, the capacity of bone marrow cells for synthesis of purines may be so limited that they depend on the liver for the supply of purines. This inference was tested experimentally by measuring the amount of formate-^{14}C incorporated into the deoxyribonucleic acid bases of bone marrow cells in control and hepatectomized rabbits.

Rabbits weighing 1·5–2·0 kgm. were used. They were bled on each of the two days before the experiment to ensure an actively regenerating marrow. Rabbit 1 was not anæsthetized, to serve as a control for the effects of anæsthesia (chloralose, 80 mgm./kgm.) in the others. In rabbits 4 and 5, as much of the liver as possible was removed (about 95 per cent). This procedure introduced two other factors which may have complicated the interpretation of the results : trauma and cessation of blood flow through the intestine. To test whether these conditions were influencing the results, further experiments were necessary. Both kidneys were removed from rabbit 3 as a control for trauma, and the intestinal tract was removed in rabbit 6. As this latter operation cut off a large proportion of the blood supply to the liver, it was repeated in rabbit 7, but with restoration of the portal blood flow by anastomosis of the inferior vena cava to the stump of the portal vein.

Five to ten minutes after the operations, sodium formate-^{14}C (500 μc./kgm., specific activity, 4 mc./m.mole) was given intravenously. The rabbits were killed by exsanguination 90 min. later and the femoral and tibial bone marrow was removed. The deoxyribonucleic acid bases in the bone marrow were isolated, and the specific radioactivity measured as described before[3]. The results are shown in Table 1.

There was little difference between the ratios of specific activity of thymine/adenine in the non-anæsthetized control, anæsthetized and nephrectomized rabbits. The mean ratio was 1·05, indicating a similar degree of incorporation of formate-^{14}C into both the purines and the thymine of the deoxyribonucleic acid in bone marrow cells *in vivo*. More labelled adenine was found in the bone marrow from the unanæsthetized rabbit, giving a ratio for the specific activity of thymine/adenine of 0·5, but because of the expenses involved, further experiments to test the significance of this difference were omitted.

In the hepatectomized rabbits, the incorporation of formate-^{14}C into the adenine of bone marrow cells was substantially depressed, thus raising the thymine/adenine ratio to 27. A similar thymine/adenine ratio was found in the rabbit where the intestine was removed, with arrest of the portal circulation. In the rabbit in which portal blood flow was restored after removal of the intestines, the thymine/adenine ratio was 3·17, indicating that formate-^{14}C was efficiently utilized in the formation of bone marrow adenine. This was in spite of the fact that intraportal injection of ink stained only about 50 per cent of the liver at the end of the experiment. In

Table 1. SPECIFIC ACTIVITIES OF THE THYMINE AND ADENINE OF DEOXYRIBONUCLEIC ACID FROM RABBIT BONE MARROW 1½ HR. AFTER AN INTRAVENOUS ADMINISTRATION OF 500 μC. FORMATE-^{14}C PER KGM. BODY-WEIGHT (COUNTS PER MIN./μM BASE)

	Rabbit 1, control, no anæsthetic	Rabbit 2, control, anæsthetic	Rabbit 3, control, nephrectomy	Rabbit 4, hepatectomy	Rabbit 5, hepatectomy	Rabbit 6, portal occl.	Rabbit 7, caval-portal anastomosis
Thymine	450	600	570	138	40	347	589
Adenine	900	380	543	5	1·5	17	186
Ratio (*T*/*A*)	0·5	1·6	1·05	28	27	20	3·17

one animal (rabbit 5) the blood pressure fell to 35 mm. mercury soon after hepatectomy and, as might be expected, the synthesis of both purines and thymine was depressed. Nevertheless, the thymine adenine ratio still indicated the importance of the liver for the synthesis of purines.

These experiments show that the *de novo* synthesis of purines in bone marrow cells is greatly reduced by hepatectomy. It is unaffected by nephrectomy or by removal of the gastro-intestinal tract, as long as the portal blood flow is maintained. Three interpretations of these results are suggested: (1) In animals, the liver provides an enzyme with which the bone marrow cells can synthesize purines. (2) The liver provides an advanced precursor which the bone marrow cells can transform into purines. (3) The liver supplies preformed purines which are taken up by bone marrow cells.

If the liver provides an enzyme, it must have a very short life, for in our experiments even 5–10 min. after hepatectomy the bone marrow cells cannot utilize formate-^{14}C efficiently for synthesis of purines.

If the liver supplies an advanced precursor to the bone marrow, then bone marrow cells *in vitro* should be able to utilize 5-amino-4-imidazole carboxamide or its riboside (one of the last steps in the purine pathway). It has recently been shown[5] that these substances are utilized very inefficiently for synthesis of purines compared with the uptake of adenine-^{14}C into purines or of formate-^{14}C into thymine.

This leaves the third possibility, which is further supported by the observations that although bone marrow cells *in vitro* have a limited capacity for purine synthesis, they can utilize preformed adenine very efficiently[6]. We can conclude, therefore, that in the mammalian organism, the liver is the main source of purines for the bone marrow cells, and possibly for the cells of most peripheral tissues.

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Elimination of Macrophage Cells of the Reticulo-Endothelial System by Way of the Bronchial Tree

IT has been demonstrated by Nicol[1] that vitally stained macrophages appear cyclically in the uterine endometrium and that they are greater in number in the follicular phase of the œstrous cycle and their number and activity may be increased experimentally by œstrogens. The dye-bearing macrophages were not observed within the uterine blood vessels although some were seen to lie close to them. The appearances throughout the uterus and vagina provided convincing evidence that the dye-bearing macrophages are similar to many of the rounded cells, with dense nuclei and no dye, frequently seen within the capillaries and passing through the blood vessel walls in the circular muscle zone. From this it was inferred that the blood is the chief source of these macrophages, although some of them may be derived from the connective tissue cells of the endometrium.

It was later shown by Nicol and his colleagues[2] that œstrogens have a strong stimulating influence on the reticulo-endothelial system generally and that this results in the appearance of large numbers of macrophages in the spleen and liver and the mobilization of these cells into the circulation. In the spleen of control animals a relatively small number of vitally stained cells was normally present in the sinuses and in the reticulum, and in the liver only a few dye-bearing Kupffer cells were seen. After œstrogenic treatment, however, the number of dye-bearing cells became considerably increased in both liver and spleen and many of these were liberated and could be seen free in the splenic sinuses, splenic vein and intralobular veins of the liver, but they were not seen in the splenic artery. The present research was designed to study the fate of the hepatic and splenic macrophages which become free and enter the bloodstream.

For this investigation 36 male white mice (T.O. Swiss strain) of 20–30 gm. body-weight were used. Each animal received one subcutaneous injection of 0·5 mgm. of œstradiol benzoate once daily for 6 days and then one injection of 4 mgm. of carbon of particle size 250 A. into the dorsal vein of the penis on the eighth day. The animals were divided into six groups and blood samples were taken under anæsthesia at either 2 min., 2 hr., 1, 2, 3 or 4 days after the carbon injection from each of the following sites—splenic vein, portal vein; hepatic vein, inferior vena cava, right heart; left heart, retro-orbital plexus, saphenous vein. The animals were then killed and smears were taken from the lungs and bronchi, and the trachea was tied at two points and an isotonic solution of saline used to wash out the contents of the lumen for microscopical examination. In addition, specimens of the liver, spleen and lungs were fixed in Heidenhain's 'Susa' fluid and sections were cut 10μ thick and stained with dilute eosin or carbol fuchsin.

The results were as follows: carbon-containing macrophages were found in the splenic sinuses, splenic vein, portal vein, liver sinusoids, intralobular veins, hepatic vein, inferior vena cava and right heart blood; but were not seen in the left heart blood, retro-orbital plexus and saphenous vein.

Two minutes after the injection a considerable amount of carbon was seen in the macrophages of the spleen and liver and a heavy concentration in the lumen of the capillaries of the lungs. Two hours later the macrophages of the spleen and liver contained a great amount of carbon, but in marked contrast no carbon was seen in the lungs. Forty-eight hours later a small number of carbon-containing macrophages was seen in the alveolar walls of the lungs, and 4 days after the injection a moderate number could be seen free in the alveoli. Carbon-containing macrophages were also found in the smears from the lungs and bronchi and in the washings from the trachea; they were well differentiated in the bronchi and lower trachea but in the upper respiratory passages they were disintegrating.

It has previously been reported[3] that when a known amount of carbon is injected intravenously about 90 per cent of the carbon is removed from the blood by the Kupffer cells of the liver, 3 per cent by the phagocytes of the spleen and the remainder by those of the bone marrow, lymph nodes and connective tissue. In the present investigation our use of œstrogens to stimulate the reticulo-endothelial macrophages and of carbon as a marker has enabled us to identify, not only the liver and spleen as the important sites of active phagocytosis, but also the distribution of the hepatic and splenic phagocytes liberated into the circulation, and their elimination by the lungs.

Florey[4] states that the lung is particularly rich in phagocytes, whatever their origin, for there is a constant demand for their activity to keep the alveoli clear of dust particles and other material. He states that in some species cells have been described within the alveolar walls which are thought to be capable of becoming detached phagocytes, but probably many of the lung phagocytes develop from blood monocytes. He also points out that it has been suggested that they may be replenished by showers of cells produced by division of the Kupffer cells of the liver which enter the circulation and are caught up in the lung capillaries. The cells then pass into the alveolar spaces and are seen there as large round cells containing particles like carbon from the air or hæmosiderin from extravasated red blood cells, and many of them probably pass up the bronchial tree.

Our results show that the blood channels within the lungs are poor in phagocytes, but that under certain conditions there is a liberation of phagocytic cells from the liver and spleen which enter the circulation and pass to the lung capillaries; and that when they contain ingested material like carbon they do not travel through the lungs into the left heart and peripheral circulation but pass into the bronchial tree and up the trachea to be expectorated or swallowed. Our evidence therefore gives support to the concept that the lung macrophages may be augmented or derived from the liver and spleen. It may be that the heart failure cells and dust cells of the lungs are also of hepatic and splenic origin.

The results appear to be of clinical significance since they indicate one method by which disease may be disseminated.

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Lack of 'Slow-Alpha' Proteins in some Guernsey Cattle

Out of about 2,500 cattle sera examined during the past two years by starch gel electrophoresis[1], two individuals were found which lacked a slow alpha (Sα) protein zone (Fig. 1). Both animals were Guernsey cattle, one a five-year-old cow and the other her twelve-month-old heifer calf. This suggests that the condition is inherited. The herd from which the cow originated was examined for the absence of Sα-proteins. The part of the pedigree which is relevant is shown in Fig. 2.

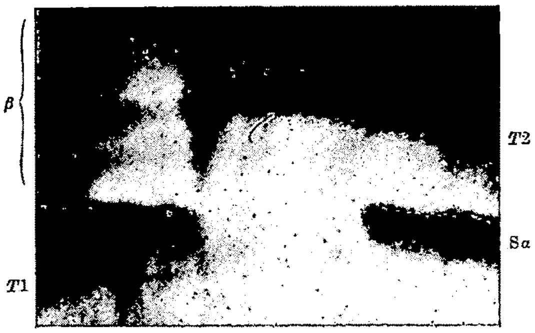

Fig. 1. Part of the anodic side of a starch-gel electropherogram carrying three cattle sera, the central one lacking Sα-proteins. β, β_2-globulins; *T*1 and *T*2, thread proteins

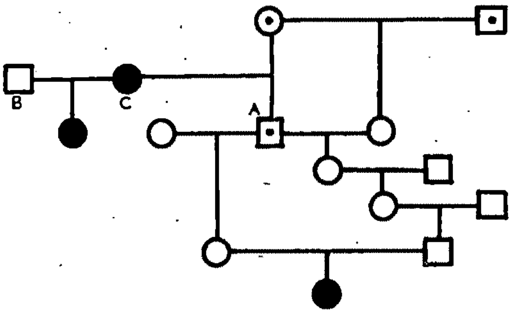

Fig. 2. Pedigree of part of a Guernsey herd in which some animals lack Sα-proteins. Solid circles denote affected females. Symbols with dots indicate animals which were not available

It seems likely that the Sα-protein (or proteins) is controlled by a pair of allelomorphic genes, $S\alpha^A$ and $S\alpha^O$. The genotypes $S\alpha^A/S\alpha^A$ and $S\alpha^A/S\alpha^O$ would then give phenotypes with Sα-proteins, while the genotype $S\alpha^O/S\alpha^O$ would lack them.

The relatively high frequency of $S\alpha^O$ in this herd seems to be due to a bull (unfortunately dead) which must have been homozygous for this allele. This particular bull (*A* in Fig. 2) was the result of a cross between two animals which had the same dam.

Insufficient information is available to assess the frequency of $S\alpha^O$. However, the bull *B* (Fig. 2), presumably $S\alpha^A/S\alpha^O$, is at present standing at a cattle breeding centre and is used extensively. No further examples of individuals lacking Sα-proteins were found among his progeny from fourteen matings picked at random from other herds.

The animals lacking Sα-proteins were in good health and did not show any signs of abnormalities. In fact, the five-year-old cow (*C*, Fig. 2) gave the best individual milk yield of cows in milk-recording Guernsey herds in Staffordshire for two successive years. Each of the bull *A*'s five daughters in the herd has shown a milk yield above average in each lactation.

The nature of the Sα-proteins in the cow is not known, but an analogous protein in humans has been shown recently by Poulik and Smithies[2] to be a glycoprotein of high molecular weight. A protein zone of this type has been found in all the mammalian sera so far examined, with the exception of the Guernsey cattle shown in Fig. 2 and two horse sera.

I wish to thank Mr. K. O'Sullivan, deputy regional veterinary officer of the Milk Marketing Board, for his generous co-operation.

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Emergence of a Summer Species of Dragonfly

Two types of British dragonfly have been recognized, namely, spring and summer species. Spring species (for example, *Anax imperator* Leach, *Pyrrhosoma nymphula* (Sulzer)) have been defined as those having a diapause in the final larval instar and, in consequence, a closely synchronized emergence. In summer species (for example, *Aeshna cyanea* (Müller), *Lestes sponsa* (Hansemann)) diapause is by definition absent from the final instar, although sometimes developed in another stage in the life-history[1]. The lack of a final instar diapause in summer species made it seem likely that emergence in this ecological group would be less closely synchronized than in spring species, and that in some cases it might inherit from the larval population a time-frequency distribution approaching normality[2]. Although emergence of *L. sponsa* has been found to be temporally dispersed[3], when compared with that of *P. nymphula*[2], its exact temporal distribution and duration have hitherto remained unknown. Recently, however, the emergence pattern of another summer species, *A. cyanea*, has been determined directly by means of exuvia counts made in Nature, and the results provide a striking confirmation of expectation.

In Fig. 1 the emergence curve of *A. cyanea* is compared with that of *A. imperator*, a spring species in the same family and of similar size. The two curves differ significantly in the degree of their synchronization, a point well demonstrated by comparing the times during which 50 per cent of the annual population emerged: this stage was reached by the third day of emergence in *A. imperator*, but not until the twenty-fifth day in *A. cyanea*. Total duration of emergence in the two species was, however, approximately the same, being 44 days and 49–55 days, respectively.

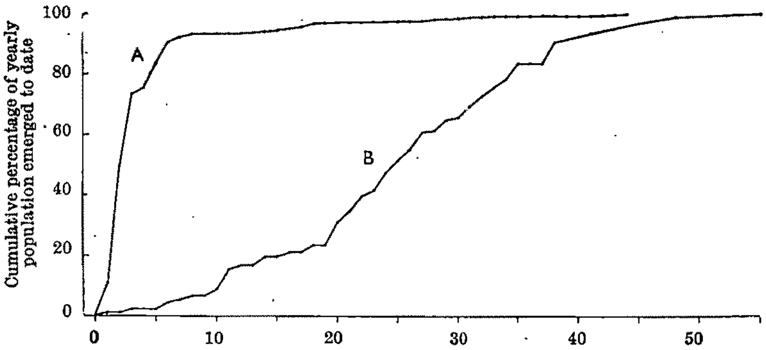

Fig. 1. Time-frequency distributions of adult emergences in (*A*) a spring species and (*B*) a summer species. *A*: *Anax imperator* in Berkshire during 1953; emergence began on May 25 and finished on July 7. *B*: *Aeshna cyanea* in Hampshire during 1957; emergence began on June 29 and finished between August 16 and 22

Such large differences in the temporal distribution of emergence will have important effects on other stages in the life-history. For example, early population pressure at the breeding site, and the resulting dispersal during the first few days of maturity, will probably be far more pronounced in spring species than in summer species. Also, the ecological demand for reproductive longevity will supposedly be greater in summer species, in which adult populations are heterogeneous with respect to the age of their members. In this connexion it is interesting to note that, in a Dorsetshire pond, Moore[4] found the flying season of *A. cyanea* to be very much longer than that of *A. imperator*.

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Feeding Habits of Emperor Penguins

The feeding habits of emperor penguins (*Aptenodytes forsteri* Gray) have been described by previous authors[1–5]. Most agree that the birds have access to the sea through tide cracks. During the winter of 1957 in Antarctica, I was able to observe this phase of the birds' activities and can now amplify previous comments.

The breeding cycle of the emperor penguin is peculiar in that it occurs in the depth of the antarctic winter. After the laying of the single egg (in May in most rookeries) the female bird leaves the rookery for approximately nine weeks while the male bird incubates it. No trace of the females is seen until hatching commences, when they return in large numbers to the rookery to commence feeding the chicks while the males go to sea to end their long fast. The chicks grow rapidly, and the constantly increasing demand for food means that both parent birds travel to and fro from the feeding places, gorging themselves with fish and krill, then regurgitating food for the chicks.

Taylor rookery (67° 28′ S., 60° 53′ E.), fifty miles west of the Australian National Antarctic Research Expedition's base Mawson, is unique in that it is situated in an old glacial valley adjacent to the sea. All other known rookeries, with the exception of the one at Dion Islets, are located on sea ice. It is flanked by a glacier on its western side and is surrounded by a ring of high hills which afford much protection from wind. During the chick-feeding period here, the majority of birds do not travel more than two or three miles to feeding holes. Between the glacier and some nearby islands are a number of tide cracks, parts of which are kept open by glacier movement, Weddell seals, and feeding emperor penguins which congregate in large numbers near these holes. An interesting fact is that the birds do not feed for very long at these holes. Presumably this is because fish and krill in the area rapidly diminish against the onslaught of many hungry birds. When this occurs the hole is deserted and the birds move elsewhere.

At this time of the year, a few birds are seen to travel seawards past the thickly populated feeding grounds, and are probably going farther afield for food, although I did not follow these birds.

A new emperor penguin rookery was discovered by an Australian party in August 1957 at approximately 67° 25′ S., 64° 00′ E. It is situated on sea ice held in by grounded bergs. At this time its population was approximately 12,000 adults and 8,500 chicks. A large feeding hole was found at the same time six miles south of the rookery at the base of a tilted iceberg. There were nearly 100 birds present, with many large groups of birds going to and from it.

The complete absence of female birds near the antarctic coast during the incubating season means that they must travel far out to sea, possibly to the pack ice fifty or one hundred miles away. However, their mode of travel is almost certainly not walking. In May several of these females were seen to enter the water through seal holes close to the Fold Island rookery (67° 20′ S., 59° 23′ E.), 90 miles west of Mawson, and appear again at more distant holes. Swimming from hole to hole beneath the sea ice would provide them with a much more rapid method of travel than walking, and it would be possible for them to cover large distances in a relatively short period.

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May 17.

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An Outbreak of Subcutaneous Tumours in Rhesus Monkeys

SUBCUTANEOUS tumours have developed in a colony of Indian rhesus monkeys (*Macaca mulatta*) at the laboratories of the West African Council for Medical Research, Lagos, Nigeria. We are using the word 'tumour' in a wide sense without any implication that the growths described are true neoplasms.

The colony in which the outbreak occurred consisted of approximately thirty-five animals housed in a row of four adjacent pens, with indoor and outdoor compartments; two further pens, situated at one end of these four pens and adjacent to them, contained various West African monkeys. A row of six smaller pens was situated 100 yards from the main rhesus pens and at the time of the commencement of the outbreak housed other assorted West African monkeys. Contact between monkeys in adjacent pens frequently occurred by the extension of a limb of one animal through to the next cage. The rhesus monkeys in the affected colony varied in age from new-born to approximately six years. The majority of adults had, at one time or another, been used for virus studies and had been returned to the pens after recovery from infection.

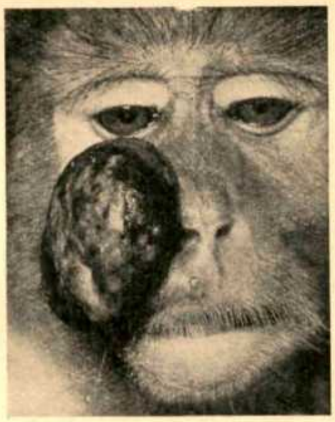

Fig. 1. Adult female rhesus monkey (case 2) with growth of three and a half weeks duration

No tumour had been observed in any species of monkey prior to June 15, 1957. On this date an adult male rhesus monkey, housed in one of the two centre pens, was seen to have a tumour, approximately 1 cm. in diameter, on the right eyebrow. During the following week the growth rapidly increased in size and an adult female situated in the other of the two centre pens was found to possess a similar growth on the nose (Fig. 1). During the ensuing weeks the condition spread rapidly, and by the end of the year had affected approximately twenty animals. In the early stages an unsuccessful attempt was made to limit the outbreak by separating tumour-bearing animals into individual cages; later, affected rhesus monkeys were placed in three of the six smaller pens normally housing West African monkeys. During October 1957, one young dog-faced baboon (*Papio papio*) situated in one of the three remaining small pens was found to have developed a tumour on the nose.

During the course of the outbreak, animals of all ages became affected by the condition. Tumours occurred most frequently on the lower portion of the limbs or dorsal aspect of the feet and hands, otherwise on the face or ears, never on the trunk. Affected animals did not appear sick or emaciated and seemed to be little inconvenienced unless suppuration of the tumours took place. During the early stages of the outbreak the condition appeared to be relatively mild, only single tumours occurring on affected monkeys; but as the outbreak assumed greater proportions an apparent increase in severity occurred, multiple tumours arising along the course of the lymphatic vessels draining a tumour-bearing area. Unless destroyed, affected animals recovered spontaneously, the growth sloughing away and the area healing by granulation. No attempt was made to treat the condition other than by local excision of tumours and the combating of secondary infection.

The tumours arose in the subcutaneous tissue, and in the earlier stages were seen as small, slightly reddened papules. Once initiated, growth ensued with great rapidity, tumours fungating through the skin and attaining a diameter of 2–4 cm. in as many weeks. At biopsy and post-mortem examinations the tumours were found to be adherent to the underlying structures and to be non-encapsulated. On section the tumours were light pink in colour and without visible structure. The regional lymph nodes

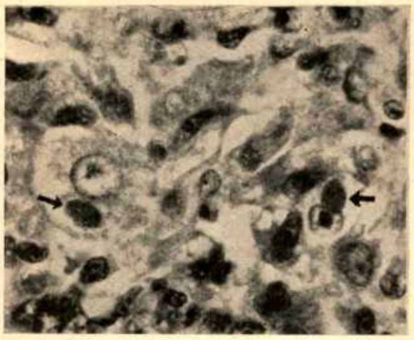

Fig. 2. Section of tumour showing cytoplasmic bodies (arrows)

were frequently enlarged but freely mobile. No metastases were found in any of the viscera in animals brought to autopsy.

Histological examinations showed that the bulk of the tumour was composed of pleomorphic cell types, the predominant cell (Fig. 2) being large with abundant cytoplasm. The cytoplasm of the majority of these cells contained one or more acidophilic, rounded or irregular bodies varying in size between 1 and 5μ and resembling virus-induced inclusions. In some cases there was a moderate degree of fibrous tissue reaction and an infiltration with inflammatory cells. No bacteria, fungi or protozoa were seen in tissue sections. In deeper layers of the growths tumour cells were frequently seen infiltrating between underlying muscle fibres. Enlarged regional lymph nodes were often seen to contain cells resembling those characteristic of the tumours.

The disease has been transmitted by subcutaneous inoculation of lightly centrifuged emulsions of tumour material to healthy rhesus monkeys and to two West African guenon monkeys (*Cercopithecus aethiops tantalus*). Attempts to transmit the condition to West African mangabeys (*Cercocebus torquatus torquatus*), to Patas monkeys (*Erythrocebus patas patas*) and to laboratory white mice have been unsuccessful.

Tumour material has been forwarded to Dr. C. H. Andrewes, National Institute for Medical Research, Mill Hill, London, for further investigation by his colleagues and himself; they have obtained evidence that the causative agent is a virus, as will be reported later.

Our thanks are due to Dr. F. N. Macnamara, director of the Virus Research Unit, for permission to publish this communication.

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Epidermal Structures in a Rhinoceros (*Ceratotherium simum*)

Most accounts of rhinoceros skin detail its more obvious characteristics, namely, its rough, wrinkled and mammillated exterior, its well-keratinized epidermis and its thick, weighty and inelastic dermis. Concerning the structure of such skin and the possible presence of epidermal derivatives (other than horns) information is curiously wanting in authoritative zoological treatises[1]. It is frequently stated that body hairs, save those constituting the ear- and tail-fringes, are lacking in the Rhinocerotidae, though Beddard[2] recognized an unobtrusive and rather sparse hairy covering as a general familial character.

Neuville[3] observed hairs around the base of the horn in the three Asiatic species (*Rhinoceros unicornis*, *R. sondaicus*, *R.* (*Didermocerus*) *sumatrensis*), and Lydekker[4] considered *Didermocerus* a form specially prone to hairiness, the so-called species '*Rhinoceros lasiotis*' being based on nothing more than a particularly hirsute specimen. Bigalke *et al.*[5] described, in an infant *Ceratotherium simum*, a very sparse hairy covering, becoming less obvious with advancing age, and we have noted a discrete hair tuft upon the nuchal eminence of an immature animal of this species. Reliable records as to the hairiness of young specimens of *Rhinoceros unicornis*, *R. sondaicus* and *Diceros bicornis* appear to be lacking.

It is probable that in some rhinoceros species at least, as in the elephant, the neonatus manifests an extremely sparse hairy coat which disappears gradually either as the result of friction or the accumulation of subcutaneous fat.

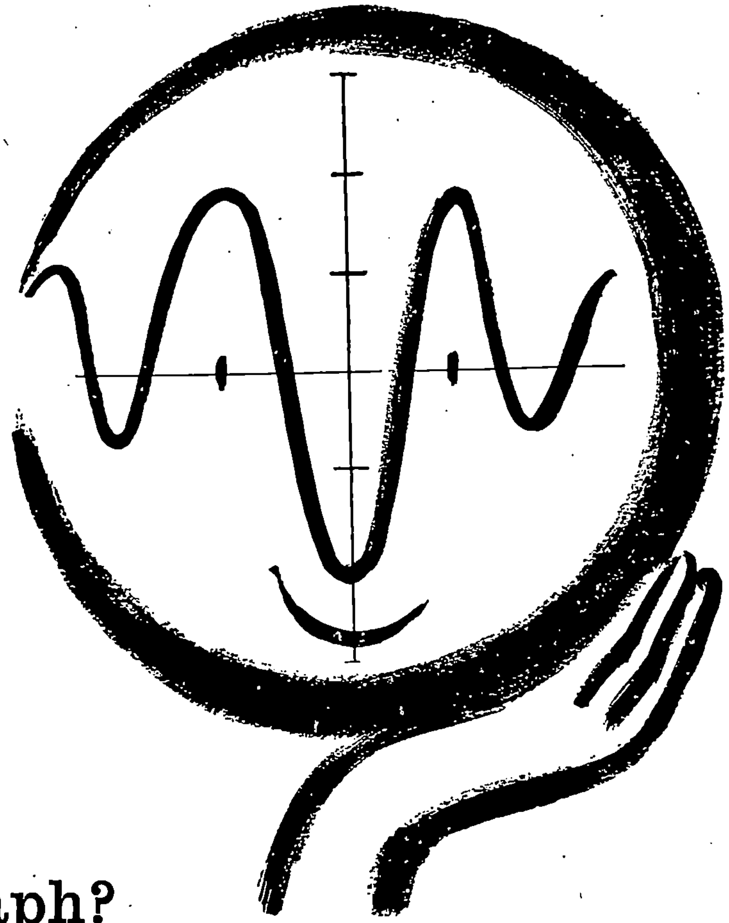
It is not surprising, therefore, that recent microscopical examination of the cervical and abdominal skin of an immature specimen of *Ceratotherium* should reveal the presence of hair follicles (provided with sebaceous glands) containing greater or lesser portions of well-formed hair shafts. Most unexpected, however, was the finding of large apocrine sweat glands, characterized by an abundance of relatively large, ectodermally developed myoepithelial cells, an anatomical arrangement clearly subserving the rapid and copious discharge of sweat.

The skin examined was freshly procured and well fixed in the field; after paraffin blocking it was sectioned with difficulty, the best sections being 15μ–20μ in thickness. These stained well with hæmatoxylin and eosin, and with Mallory's triple stain.

Study of these skin sections reveals (*a*) a heavily keratinized and pigmented epidermis, 1 mm. thick, showing the customary component layers save for a stratum lucidum, (*b*) an exceedingly thick (18–20 mm.) and dense dermis, composed exclusively of pure collagen fibres disposed in every direction to the skin surface, and (*c*) hair follicles, hairs, sebaceous glands and apocrine sweat glands. The entire skin appears remarkably vascular. The ordinary small type of sweat gland is not observable.

The obtrusively large apocrine sweat glands are not particularly numerous, although estimation of their incidence is precluded by the thickness of the sections. Each gland surrounds, in open basket fashion, the base of a hair follicle and appears to be supplied by an independent arteriole: its spiral duct is fairly capacious in its intra-dermal course, but narrows perceptibly in its intra-epidermal course. A striking feature of the glands and ducts is the association therewith of large and numerous ectodermally developed myoepithelial cells: these lie between the secretory cells and the basement membrane of the glands and are disposed helicoidally around the ducts.

These distinctive apocrine sweat glands seem to have escaped previous notice in *Ceratotherium* and it is not known whether they occur in other rhinoceros species. Histologically the skin of *Ceratotherium* is demonstrated to be of typically mammalian constitution and to lack none of the customary epidermal derivatives. It is specialized in respect of the degree of keratinization of its epidermis, the thickness and



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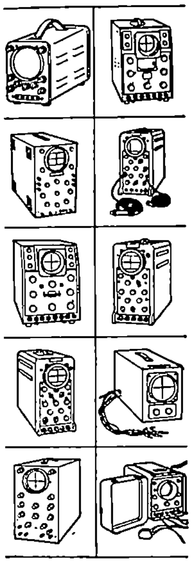

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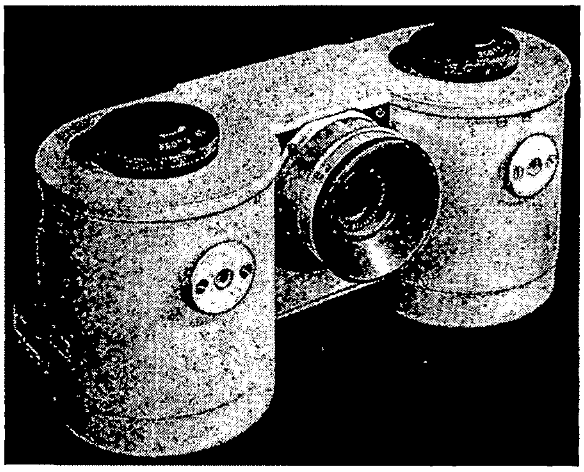

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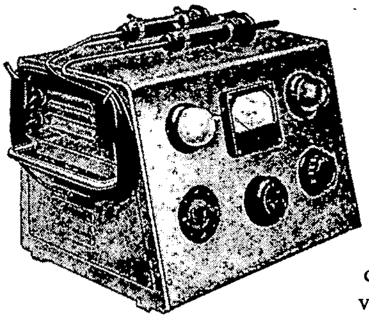

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purely collagenous nature of its dermis and the size and structure of its peculiar sweat glands.

A detailed account of the skin histology will be published elsewhere.

We are deeply indebted to Dr. E. H. Williams, of Arua, for the collection and preservation, under difficulty, of the material studied.

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Lolium temulentum L., a Long-day Plant requiring only One Inductive Photocycle

COOPER[1] has recorded that *Lolium temulentum* is a long-day summer annual which shows no response to vernalization by low temperatures, and has no sharply defined critical photoperiod. My results, however, indicate that at least one strain of the species is a strict long-day plant, and that it can be induced to form normal inflorescences by exposure to only one long day.

The plants used were derived from the selfed progeny of a single Canadian plant, and were grown under controlled environmental conditions in the Earhart Laboratory, Pasadena. After seedling establishment in 8-hr. photoperiods, groups of plants were distributed to a series of photoperiod regimes at 17° C. under mixed incandescent and fluorescent illumination at an intensity of 1,200 ft.-candles throughout the photoperiod. The times of inflorescence initiation were determined by periodic dissection, and it may be seen from Table 1 that initiation was considerably delayed in photoperiods less than 12 hr. in length, and did not occur in 9-hr. photoperiods within 180 days. Initiation of inflorescences in this strain of *L. temulentum* thus appears to have an absolute requirement for long days.

Table 1. NUMBER OF DAYS REQUIRED FOR THE INITIATION OF INFLORESCENCES IN PLANTS OF *L. temulentum* GROWN AT 17° C. UNDER INCANDESCENT AND FLUORESCENT ILLUMINATION AT AN INTENSITY OF 1,200 FT.-CANDLES

Photoperiod length (hr.)	8	9	11	12	13	15	24
Days to double ridge appearance	—	>180	95	28	18	14	8

Groups of plants, which had been grown for five weeks in 8-hr. photoperiods, were exposed to a varying number of long days at 23–17° C. before being returned to short-day conditions. The rates of development of their inflorescences in short days at 23–17° C. subsequent to induction were determined by the dissection of five plants in each treatment group each week. All plants received 8 hr. of natural illumination daily, and during treatment were given photoperiod extensions at intensities of 12, 40 or 400 ft.-candles at plant height. Both continuous light and 16-hr. photoperiods were used for induction. Of the plants not exposed to long days, none showed any sign of inflorescence initiation within 140 days. Their apices did, however, increase in length throughout the period of the experiment, due to the accumulation of unexpanded leaf primordia. On the other hand, all the plants exposed to long-day conditions in all series, even those exposed to only one 16-hr. photoperiod of low intensity, either eared or displayed unambiguous inflorescence initiation on dissection. This strain of *L. temulentum* thus has a sensitivity to photoperiodic induction comparable to that of *Xanthium pensylvanicum* among short-day plants. It should be noted, however, that maximum photoperiodic sensitivity is not attained until the plants have been grown for about five weeks in short-day conditions at 23°–17° C. After only 14 days in that regime the plants need four days of continuous light for induction, while seedlings 21 and 26 days old require, respectively, three and two days of continuous light.

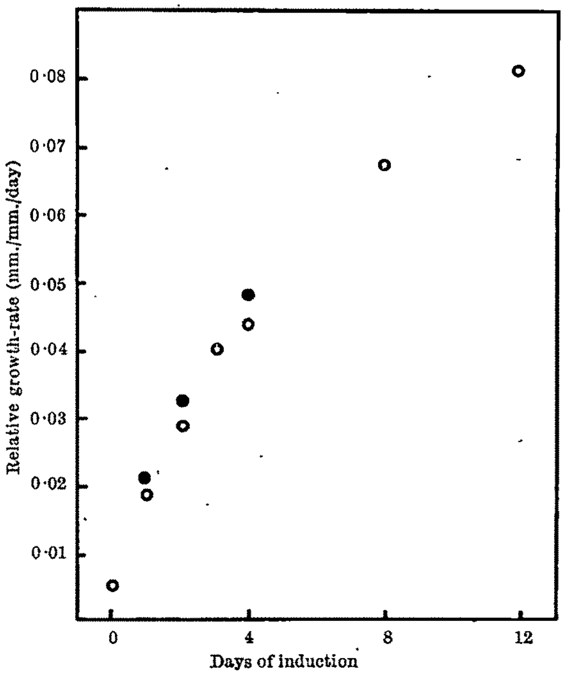

Fig. 1. The effect of the number of days of continuous light induction on the relative growth-rate of inflorescences of *L. temulentum* in 8-hr. photoperiods at 23–17° C.: with day-length extensions of 400 ft.-candles intensity, ○; with day-length extensions of 40 ft.-candles intensity, ●

In the controlled environmental conditions available for these experiments, the increase in apex length among induced plants was exponential with time, and it may be seen from Fig. 1 that the relative growth-rate of *L. temulentum* inflorescences, in 8-hr. photoperiods at 23–17° C. after initiation, was greatly affected by the number of long days to which the plants had been exposed. The rates were, in fact, approximately proportional to the logarithm of the number of inductive photocycles given. They were, moreover, highly reproducible, and provide a sensitive index for kinetic analyses of the inductive process.

Variation in the number of long days to which the plants were exposed had no effect on the number of spikelets formed in each inflorescence, nor were teratological features, such as sterility or vegetative proliferation, evident in any of the minimally induced inflorescences. This implies that there is a homeostatic canalization of inflorescence development (cf. ref. 2) whereby regulation of the rate of differentiation allows normal morphogenesis to occur in this species even under conditions of sub-optimal induction.

This work was supported by the Commonwealth Fund of New York.

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[1] Cooper, J. P., *J. Agric. Sci.*, **47**, 262 (1956).

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Chirality

The importance of particle parity, non-symmetric tensors in crystals, and other mirror-image properties, requires that a previous communication[1] be amplified, which suggested that, following Kelvin[2], Larmor and Eddington, the term 'chirality' be used for the property characterizing three-dimensional forms not superposable on their mirror images. Kelvin wrote[3] "I call any geometrical figure, or any group of points, *chiral*, and say it has *chirality*, if its image in a plane mirror, ideally realized, cannot be brought to coincide with itself". Unfortunately the definition in the Oxford English Dictionary—"*chiral*, the power of certain crystals and optically active substances of turning the plane of polarization of light to the right or left hand"—is not only less fundamental but misleads, since it is theoretically possible for crystals of four non-enantiomorphous classes (m, $mm2$, $\bar{4}$, $\bar{4}2m$), which are not chiral in Kelvin's sense, to display optical activity[4], though no example has yet been positively established.

The following generalization of Kelvin's definition is proposed (and has been offered for use in the next Supplement to the Oxford English Dictionary): 'three-dimensional forms (in the widest sense, including point arrangements, structures, fields, displacements, and other processes, periodic and relaxation) which possess non-superposable mirror images are called chiral'. This is a three-dimensional non-relativistic property; a chiral process is one the successive states of which are chiral. The necessary and sufficient condition for the presence of chirality is the absence of all three of the following symmetry elements: a plane of symmetry, a centre of symmetry, and any $4n$-fold inversion axis. The definition applies both to mathematical forms and to observed phenomena, and does not presuppose their representation in any particular manner (for example, in a linear, or any other co-ordinate system, etc.) provided the conceptions of mirror images and of superposition (by rotations) are applicable.

The terms 'chiral', 'chirality', 'chiroid' (for chiral object or process) are short, enjoy a distinguished tradition, and can be given an unambiguous and comprehensive definition. Alternative terms are either less general or vague: 'enantiomorphous', though in origin expressing the same idea, has acquired a narrower application through usage for the eleven chiral classes of point group symmetry and for crystals of these classes; 'asymmetrical' has an established meaning for carbon atoms and other chemical centres, but is otherwise ambiguous; 'non-symmetric' is best restricted to tensors; 'dissymmetric' has been used for chiral molecules and crystals, but not widely adopted; chemically 'isomeric' molecules may not be chiral; while 'anti-symmetrical' has a special meaning[5]—operations of anti-symmetry transform objects possessing two possible values of a given property from one value to the other.

Chiral forms are more varied and widespread than is sometimes realized. Some examples are: (mathematical) skew polygon, pair of skew lines, area with sense, various skew polyhedra, for example, an isosceles tetrahedron with scalene faces and Coxeter's "orthoscheme", helix, helical polygon, scalene spherical triangle, single overhand knot, eleven enantiomorphous classes of point group symmetry, ratio of two co-initial vectors, associations of a polar with an axial vector, quaternions, spinors, non-symmetric three-dimensional tensors, pseudo-scalar fields; (natural) most optically active molecules, crystals of the eleven enantiomorphous classes, many electromagnetic fields, screw displacements, body torques, torsions, relaxation processes of chirally deformed structures, amino-acid and protein structures, conical helices in plants and shells, many parts of animals (including the human hand); (man made) coat with buttoning for man or for woman, shoe, propellor, clock face. They merit a clear designation.

Note added in proof. 'Helicity' is a special case of chirality, involving helical properties with respect to an axis. Recent examples of chiral forms are the neutrino and the chiral operator of particle theory (Watanabe, *Phys. Rev.*, 106, 1306; 1957).

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Motion of the Nodal Line of the Second Russian Earth Satellite (1957β) and Flattening of the Earth

Despite the fact that the observation of an artificial satellite can be carried out only on a small region of the Earth's surface, we can use these measurements for determining the geocentrical co-ordinates of the satellite, if we know the approximate value of its distance from the Earth's centre. The most suitable observations are those in the neighbourhood of the zenith. If we know the inclination of the orbit, we can then determine also the position of the orbital node.

In order to determine the motion of the orbital node, we used 33 visual observations, made between December 7, 1957, and March 21, 1958, at various places in Czechoslovakia. By adjustment of the positions of the node grouped about five normal positions, the following expression for the right ascension of the ascending node was derived:

$$\Omega = 256{\cdot}59^\circ \pm 0{\cdot}20^\circ - (2{\cdot}9007^\circ \pm 0{\cdot}0046^\circ)(t-t_0) - (0{\cdot}00234^\circ \pm 0{\cdot}00012^\circ)(t-t_0)^2$$

Epoch t_0 = January 22·0, 1958, U.T. Time t is expressed in days. The mean errors were computed from the deviations of the normal places. The daily motion of the node is then given by :

$$\frac{d\Omega}{dt} = -2{\cdot}9007^\circ \pm 0{\cdot}0046^\circ - (0{\cdot}00468^\circ \pm 0{\cdot}00024^\circ)(t-t_0)$$

It is well known that the theoretical value of this motion is given by the approximate equation :

$$\frac{d\Omega}{dt} = -\frac{3k(C-A)}{2ma^{7/2}}(1+2e^2)\cos i$$

where $C - A$ is the difference between the moments of inertia of the terrestrial spheroid, m the mass of the Earth and k the gravitational constant. The symbol a stands for the major semi-axis of the orbit, expressed in units of the equatorial radius of the Earth, e and i being the eccentricity and inclination of the orbit, respectively.

It is obvious that, by using this equation, we can derive from the observed motion of the node the quantity $K = \frac{C-A}{m}$. If, for the time $t = t_0$, we assume $a = 1{\cdot}1127 \pm 0{\cdot}0003$ and for e and i the values published by D. G. King-Hele[1], namely, $e = 0{\cdot}0731 \pm 0{\cdot}0005$, $i = 65{\cdot}29^\circ \pm 0{\cdot}03^\circ$, we then arrive at :

$$K = 0{\cdot}0010856 \pm 0{\cdot}0000024$$

The mean error was computed as the total effect of the errors of the basic data. The oblateness of the Earth, α, can be computed from the expression :

$$\alpha = \frac{3}{2}K + \frac{h}{2} + \frac{3}{4}(3K^2 + Kh - h^2)$$

where h is the ratio of the centrifugal force to the value of gravity at the equator.

The reciprocal value of the Earth's flattening is then :

$$\frac{1}{\alpha} = 297{\cdot}7 \pm 0{\cdot}3$$

If we use four more values for a and e determined[2] between February 10 and March 3, 1958, we arrive finally at the result :

$$K = \frac{C-A}{m} = 0{\cdot}0010883 \pm 0{\cdot}0000014$$

$$\frac{1}{\alpha} = 297{\cdot}4 \pm 0{\cdot}2$$

In these numerical results approximate account was taken of the second term of the disturbing function.

These preliminary results show that satellite observations of greater precision will give us the possibility of determining correctly the oblateness of the Earth.

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Effect of Oxygen on the Electron Spin Resonance Spectrum of α,α′-Diphenyl-β-picrylhydrazyl

IT has been found that under certain conditions gaseous oxygen can have a marked effect on the electron spin resonance line of α,α′-diphenyl-β-picrylhydrazyl. Normally that substance crystallizes with one molecule of solvent per radical and does not exhibit this 'oxygen effect'. It is possible, however, to remove most of this solvent by heating the radical at 80° C. under high vacuum for several days. (There is no evidence that the radical is destroyed by this treatment.) The magnitude of the resonance line from a treated sample of α,α′-diphenyl-β-picrylhydrazyl depends strongly on the pressure of oxygen over the sample. The effect is similar to that observed in carbons, and appears to be a combination of the two extreme cases reported[1].

The electron spin resonance measurements were made at room temperature using a 3-cm. wave-length crystal-video spectroscope. The dependence of the width and apparent intensity of the resonance line on oxygen pressure has been studied (Fig. 1). In addition, the effect of altering the percentage of oxygen in an oxygen–nitrogen mixture has been observed. These latter results are identical with the former if the amount of oxygen present in the mixture is expressed in terms of its partial pressure. In both cases the effect of oxygen on the electron spin resonance line was completely reversible.

When the atmosphere surrounding the sample was changed from oxygen to nitrogen, or vice versa, a corresponding change in the resonance line occurred almost instantaneously. The fact that this change could be produced simply by displacing one gas by the other suggests that there is a dynamic interaction occurring between oxygen molecules and the unpaired electrons of the α,α′-diphenyl-β-picrylhydrazyl.

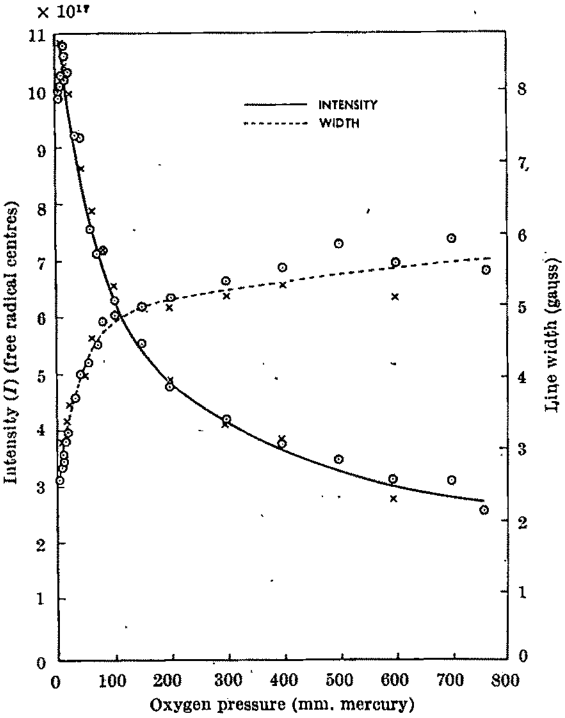

Fig. 1. Variation of intensity and width of resonance line with pressure of oxygen

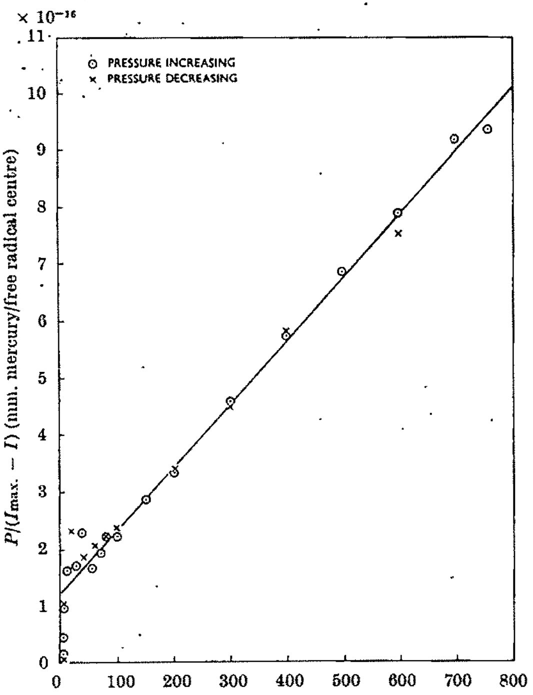

Fig. 2. Langmuir plot for adsorption of oxygen on α,α'-diphenyl-β-picrylhydrazyl

The results indicate that the interaction is physical rather than chemical in nature. It is unlikely that the decrease in the intensity of the resonance line is due to an actual decay of the free radical concentration, but that the line is broadened beyond detection. This broadening would appear to be similar to that postulated for carbon[2], where the interaction with the oxygen molecules decreases the spin-lattice relaxation time of the free radical spin system.

If the apparent decrease in the resonance line is assumed to be proportional to the volume of oxygen adsorbed, a reasonable plot of the Langmuir equation[3]:

$$p/v = 1/v_m b + p/v_m$$

can be obtained for pressures greater than 25 mm mercury. The value of the adsorption constant, b over this range is 7×10^{-6} dynes^{-1} cm.^{2}.

The electron spin resonance spectra from powdered samples of 1 : 3-dimethyl-1-(phenylimine oxide)-butylidene-3-N′-phenyl-N′-oxynitrogen[4] and 2 : 6-di-tert.-butyl-4-(3 : 5-di-tert.-butyl-4-oxocyclohexa-2 : 5-dienylidenemethyl) phenoxy[5] do not show any dependence on the oxygen pressure. However, dissolved oxygen causes a marked broadening of the spectrum from a dilute solution of the latter radical, and a slight broadening in the case of α,α'-diphenyl-β-picrylhydrazyl.

We wish to thank the Directors of 'Shell' Research Limited for permission to publish this communication.

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Entry of Water into Silica Glass

SOME specimens of silica glass absorb infra-red radiation of wave-length near 2·7μ. Garino-Canina[1] observed that the occurrence or absence of the band in his specimens depended on whether or not water vapour was present when the glass was made (by fusing quartz crystal). Following Harrison[2], he attributed the absorption to hydroxyl groups bound to some of the silicon ions of the glass.

We have demonstrated the ability of the absorbing centres to diffuse into the glass at temperatures low compared with the softening point. Values of diffusion coefficient and solubility have been obtained.

Specimens not showing the absorption band were heated at constant temperature and in a constant pressure of water vapour. The optical density of the band ($\log_{10}(I_0/I)$, where (I_0/I) is the ratio of radiation incident on the specimen to that transmitted) increased with the square root of time, suggesting that the number of absorbing centres present at any time was controlled by a diffusion process within the glass.

The distribution of the absorbing centres inside the laminar specimens of glass used was investigated by sectioning. The optical density was measured at each stage after successive layers of thickness about 10μ were removed from the surfaces of the specimen by grinding and re-polishing. Considerable penetration was found: for example, after 36 hr. at 1,160° C., absorption was detectable to a depth of 200 μ. The penetration profile appeared to be smooth and of the shape to be expected for diffusion in the existing boundary conditions.

The diffusion coefficient of the absorbing centres was determined as follows. One 'thick' and one 'thin' specimen were heated under the constant conditions of temperature and pressure of water vapour. The thickness of the 'thick' specimen was large compared with the diffusion distance, while that of the 'thin' one was small enough to allow saturation of the glass with the absorbing centres to be reached during the experiment. With the assumptions that the concentration of centres in the saturated thin specimen was uniform, and that this concentration was identical with that at the surface of the thick specimen (both assumptions being supported by experimental evidence from the sectioning work), the diffusion coefficient, D, was evaluated directly from the optical densities of the two specimens. Between 600° C. and 1,200° C., D could be represented by:

$$D = (1{\cdot}0 \pm 0{\cdot}2) \times 10^{-6} \exp\left(-\frac{18300 \pm 500}{RT}\right) \text{ cm.}^2 \text{ sec.}^{-1}$$

where R is the gas constant in cal./mole and T is the absolute temperature.

If the water reacts with the glass to form groups of the type (—Si—OH), their number may be estimated from the optical density provided the extinction coefficient is known. An estimate of the value of this coefficient was made by determining the extinction coefficient for the hydroxyl group in the unassociated molecule of triphenylsilanol (in which the —Si—OH group also occurs). The observed optical densities then led to values of solubility, under a pressure of 700 mm. mercury water vapour, ranging from 6×10^{-3} to 3×10^{-3} hydroxyl groups per 'silica molecule' between 600° and 1,200° C., respectively.

The dependence of the equilibrium concentration of absorbing centres on pressure of water vapour at constant temperature is at present under investigation.

One of us (A. J. M.) thanks the Director of the British Ceramic Research Association, for leave of absence and financial support.

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Diffusion of Adsorbed Molecules

In a recent monograph[1], Carman dismisses the suggestion that the spreading pressure φ is the operative force in the diffusion of adsorbed molecules with the statement that the coefficient of resistance of such an equation varies more rapidly with concentration than does the diffusion coefficient of Fick's equation. In presenting his arguments for this view, Carman gives for diffusion under a spreading pressure the equation:

$$-\frac{W_s}{At} = B_\varphi \frac{\partial\varphi}{\partial x} \tag{1}$$

where W_s/At is the number of moles diffusing across unit area of adsorbent in time t under the influence of a gradient $\partial\varphi/\partial x$ of the spreading pressure. $1/B_\varphi$ is a two-dimensional resistance constant.

This equation does not represent the theory previously presented by me for the diffusion of adsorbed molecules. In the development of the equations for diffusion[2], I assumed the fundamental dynamical equation for the diffusion of an adsorbed gas to be:

$$\frac{\partial\varphi}{\partial x} + C_r u = 0 \tag{2}$$

where C_r is a coefficient of resistance and u is the resultant velocity of motion of the adsorbed film on the surface. From this equation,

$$u = -\frac{1}{C_r}\frac{\partial\varphi}{\partial x} \tag{3}$$

and

$$\frac{W_s}{At} = \frac{Nu}{N_A} = -\frac{N}{C_r N_A}\frac{\partial\varphi}{\partial x} \tag{4}$$

where N is the number of adsorbate molecules per unit volume of adsorbent and N_A is Avogadro's number. Equation 4 differs from equation 1 by the factor N and the presence of N destroys Carman's argument.

In these equations it is assumed that C_r, which is equal to the resistance force per unit volume at unit velocity, is a constant independent of N. An alternative assumption is that the resistive force per molecule is independent of N. This second assumption was investigated in a subsequent paper[3] and was found to be unsatisfactory. If C_m is the coefficient of resistance per adsorbed molecule:

$$C_r = C_m N \tag{5}$$

and

$$\frac{W_s}{At} = \frac{Nu}{N_A} = -\frac{1}{C_m N_A}\frac{\partial\varphi}{\partial x} \tag{6}$$

This equation is equivalent to equation 1 used by Carman. His argument, therefore, applies only to an equation which had already been tested and rejected.

The assumption in equation 2, that the resistive force per unit volume is independent of N, requires that the resistive force per molecule varies as $1/N$. Since it is natural to assume that resistive forces are proportional to the energy with which the molecules are bound to the surface, we should expect equation 2 to be applicable only to adsorptions where the differential heats are inversely proportional to the number of atoms adsorbed. That the equation can be applied to the diffusion of adsorbed gases is undoubtedly due to the fact that most heats of adsorption can be roughly represented by a hyperbolic curve. It follows from these arguments that, when this is not so, or when more precise representation is required, it will be necessary to use an expression for the resistive force that corresponds more closely to the measured heats of adsorption.

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[1] Carman, P. C., "Flow of Gases through Porous Media", 122 (Butterworths Scientific Pub., London, 1956).

[2] Babbitt, J. D., *Can. J. Research*, A, **28**, 449 (1950).

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In the brief treatment of Babbitt's theory in my book, equation 1 of the above communication was used, and it was pointed out that, with the experimental data available, B_φ, instead of being a constant, actually varied more rapidly with surface concentration than the surface diffusion coefficient which arises from Fick's equation. Babbitt now points out that, in the form of the theory which he has advocated, the correct expression is given by equation 4. According to this, the quantity which should be constant is not B_φ, but B_φ/N, where N is a measure of the surface concentration.

When this was applied to the data of Carman and Raal, it was found that B_φ/N in all cases varied much less than the surface diffusion coefficient and sometimes showed a remarkable constancy. Thus, for 'Freon 12' (CF_2Cl_2) on Linde silica, it showed little variation from a surface concentration of about one-half monolayer to about two and one-half monolayers, even though the surface diffusion coefficient passes through a maximum in this range. At higher concentrations it increases, but this could probably be ascribed to the action of capillary forces on capillary condensate. For sulphur dioxide on Linde silica, it is not quite so constant, but increases very little from one-half to two and one-half monolayers. Thereafter it rises fairly rapidly. In the case of 'Freon 12' and of carbon dioxide on 'Carbolac', it is only possible to state that, on the whole, the range of variation is less than for the surface diffusion coefficient; but it is not possible to distinguish any range where B_φ/N is even approximately constant.

As explained by Babbitt, a constant value of B_φ would result if the coefficient of resistance per adsorbed molecule were independent of surface concentration. This seems a natural assumption to make, but it was rejected by Babbitt because it did not fit the results of King for diffusion of water vapour through horn. He has preferred, therefore, to assume B_φ/N or C_r is a constant, and, on this basis, it can be seen that his theory deserves serious consideration, though it does not apply quantitatively to all systems.

Note added in proof. A rather remarkable further confirmation of Babbitt's equation has been given recently by Gilliland, Baddour and Russell[1] for flow in porous glass plugs.

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Rubidium Depletion in Feldspars

The close geochemical coherence of potassium and rubidium has been emphasized in a number of papers by Ahrens and co-workers[1-4].

This coherence is shown in Fig. 1. The dashed lines on the diagram indicate the limits of scatter of Ahrens's original data, and most subsequent analyses fall within these limits, which are taken to indicate the limits of 'normal' potassium/rubidium ratios. In view of the close coherence of potassium and rubidium in a wide variety of igneous, metamorphic and sedimentary rocks (as well as chondritic meteorites and tektites), variations in the potassium/rubidium ratios beyond the normal limits indicate extreme processes, capable of fractionating potassium and rubidium (providing that the analyses are of satisfactory precision and accuracy).

Relative enrichment in rubidium has long been known from the special geological environment of large pegmatite bodies[2,5]. This has usually been ascribed to extreme magmatic or metamorphic differentiation causing the 10 per cent difference in ionic radius between K^+ (1·33 A.) and Rb^+ (1·47 A.) to become effective. The points lying in area I of Fig. 1 represent analyses of alkali feldspars from some large pegmatites. Recently, the same trend has been recognized in some rhyolites and granites which have crystallized from highly fractionated magma[6]. The analyses of these rocks fall in area II of Fig. 1.

Relative impoverishment or depletion of rubidium has occasionally been noted in rocks (Ahrens, personal communication; Upton, personal communication; Heier, unpublished results) and some published results of Tolmachev and Filipov[7] indicate high potassium/rubidium ratios in nepheline[5].

Recent work at Oxford has provided definite anomalously low rubidium values in several alkali feldspars. In view of the established potassium/rubidium coherence these few abnormal potassium/rubidium ratios indicate unusual conditions. These analyses fall in area III of Fig. 1.

The feldspars which have abnormal ratios come from arendalite (=charnockite) near Arendal, South Norway (full circles, Fig. 2), and syenites and monzonites (crosses) from granulite facies rocks at Langøy, Lofoten Islands, Northern Norway. These feldspars are mesoperthites[8].

In Fig. 2 the calculated orthoclase (*Or*), albite (*Ab*) and anorthite (*An*) values for these feldspars are plotted. The shaded area represents the composition of about eighty alkali feldspars with normal potassium/rubidium ratios. This figure is a projection of the quaternary system $NaAlSi_3O_8$(*Ab*)–$KAlSi_3O_8$(*Or*)–$CaAl_2Si_2O_8$(*An*)–H_2O at 5,000 bars water pressure[9]. Analyses are plotted as weight per cent *Or*, *Ab* and *An*. The cotectic curve separating the fields from which *OrAb*-rich feldspars and *AbAn*-rich feldspars crystallize out is indicated.

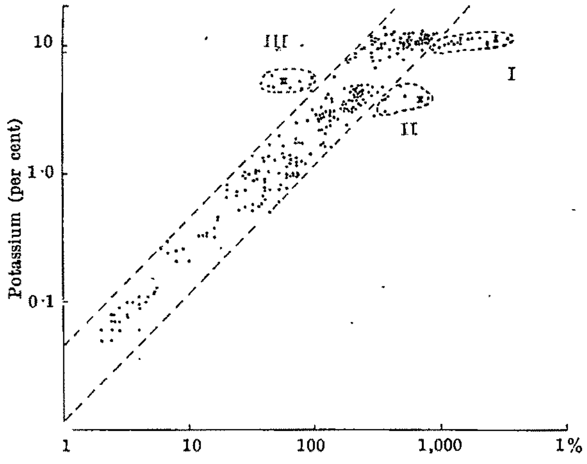
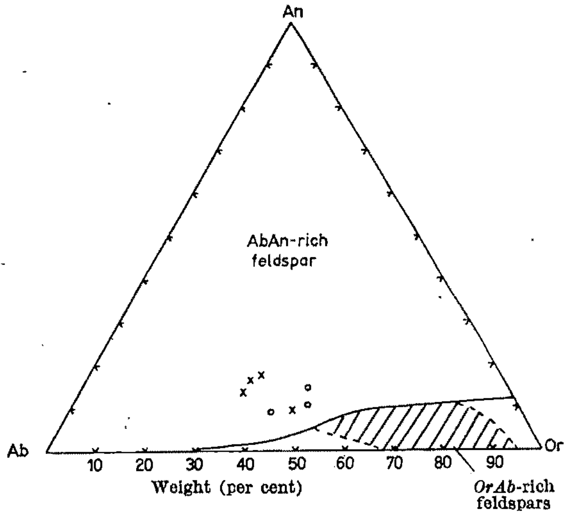


Fig. 1. Potassium–rubidium relationship for rocks and meteorites. Dashed lines indicate limits of scatter of 'normal' potassium/rubidium ratios. Area I includes feldspars from large pegmatites showing enrichment in rubidium; area II includes granites and rhyolites enriched in rubidium (ref. 6); area III includes feldspars depleted in rubidium

Our results indicate that rubidium is preferentially excluded from alkali feldspars, which, although containing substantial amounts of potassium, have a composition which places them in the *AbAn*-rich field of Fig. 2, but close to a composition from which an *OrAb*-rich feldspar would crystallize as a stable phase. It is of interest to note that the *AbAn*-rich feldspars impoverished in rubidium lie close to the maximum of the subsolidus curve for alkali feldspars separating the one and two feldspar regions, indicating maximum instability for a single feldspar phase. Where an *AbAn*-rich phase separates, the number of co-ordination sites available for potassium must be



Key: ○ Arendalite; ×, Syenites–monzonites Langøy

Fig. 2. Feldspar compositions plotted on the projection of the quaternary system $NaAlSi_3O_8$(*Ab*)-$KAlSi_3O_8$(*Or*)-$CaAl_2Si_2O_8$(*An*)-H_2O at 5,000 bars water pressure (ref. 9). The shaded area represents the composition of about 80 alkali feldspars with normal potassium/rubidium ratios

restricted. In this case, the 10 per cent difference in size is liable to become critical, and K^{+} may preferentially enter the lattice at the expense of RB^{+}. If much Ba^{2+} (1·34 A.) is present this may also occupy the high co-ordination sites to the exclusion of rubidium. This hypothesis for rubidium depletion implies that the feldspar crystallized as a homogeneous phase, and that in these cases the mesoperthite structure is due to unmixing and not to replacement.

It should be noted that a purely structural explanation for the exclusion of rubidium cannot be completely valid, since plagioclase feldspars have normal potassium/rubidium ratios. (This is indicated by the normal ratios of basic and intermediate igneous rocks, and also by the few analyses of plagioclase feldspars available.)

The additional factor seems to be the concentration of potassium in the system from which the feldspar is crystallizing. In the cases where rubidium is depleted, the system has a composition very close to the point where an independent *OrAb*-rich feldspar will appear as the stable phase. Potassium is thus very abundant and may be thought of as 'forcing' itself into the crystal lattice, which has a restricted number of sites for large ions. Rubidium, present in much smaller amounts and at a size disadvantage in this competition, will be excluded in favour of potassium in this somewhat unusual case.

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Invertase Activity in Clay Mineral - Soil Mixtures

It has been demonstrated that clay minerals can inhibit several enzymes. For example, adsorption of yeast invertase on kaolinite produces a partial inactivation of the enzymic activity, which however continues slowly[1]. By adsorption of yeast invertase on bentonite at *p*H 2·9 the enzyme is rapidly inactivated[2]. The activity of nuclease is also reduced in presence of bentonite[3]. Montmorillonite, illite and kaolinite inhibit several phosphatases[4]. McLaren has also reported that adsorption of enzymes on kaolinite may lead to a reduction or complete loss of their activity[5]. Cellulase and hemicellulase activity is reduced in the presence of montmorillonitic clays[6]. From these experiments, suggestions have been made of the possible role of the inhibition of enzymes by clay minerals in the hydrolysis of organic compounds in soil, and in humus formation.

Soil, such as clay minerals, adsorbs enzymes such as jackbean urease[7] and yeast invertase[8]. It has also been observed that added enzyme (wheat bran phytase) is not inactivated by soil[9]. The original phosphatase content of the soil suffers no reduction in its activity when clay minerals are added to soil[10]. My previous investigation[11] showed that the original natural invertase of the soil, like phosphatase, undergoes no inactivation in clay mineral – soil mixtures; on the contrary, I observed a very much increased invertase production in these mixtures, induced by the specific enzyme substrate (sucrose).

If, in these clay mineral – soil mixtures, the original natural invertase content of the soil is protected from the inhibiting action of the clay minerals, then it is still uncertain if this protective effect of the soil is a general property and so valid also for an added invertase preparation.

This problem has been studied with a neutral degraded chernozem soil (humus content 4·27 per cent), kaolinite (*S* value, 9·60 m.equiv./100 gm.; *T* value, 18·90 m.equiv./100 gm.), bentonite (*S* and *T* values, 55·60 m.equiv./100 gm.), and a yeast invertase preparation. One series of samples contained clay minerals in different quantities plus a constant volume of the yeast invertase solution; another series contained clay minerals in different quantities plus a constant quantity of soil (20 gm. air-dry soil) plus a constant volume of the yeast invertase solution. As controls, we used soil alone and yeast invertase alone. To all samples toluene was added to suppress microbiological activity, buffer solution (2 *M* Na_2HPO_4 / 2 *M* CH_3COOH, 1 : 1) at *p*H 5·5, and sucrose solution as enzyme substrate. Incubation was for 4 hr. at 37° C. The rate of inversion was determined polarimetrically. For obtaining clear solutions for polarimetry, our previous procedure was used[12]. For polarimetry we used a 2-dm. tube with light from a sodium lamp, and a temperature of 20° C. Invertase activity is expressed as the difference between rotations before and after incubation. No adsorption was observed of the sucrose or its hydrolysis products by the clay minerals, soil or the mixtures used. The results of the invertase activity determinations are given in Fig. 1.

It can be seen that the clay mineral – soil mixtures, like soil, have only a minimal inhibiting action on the yeast invertase; the attenuation of the activity of yeast invertase by the clay minerals is prevented by adding soil to the clay minerals.

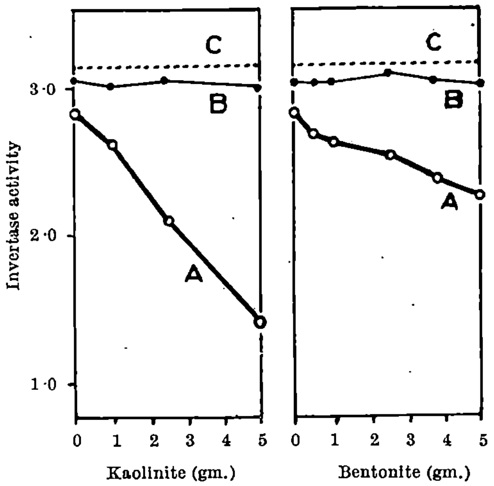

Fig. 1. Activity of yeast invertase in the presence of clay minerals, *A*, and of clay mineral – soil mixtures, *B*. The straight line *C* represents the sum of the activities of the soil invertase alone and of yeast invertase alone

This work indicates that data on enzyme inhibition by clay minerals cannot be applied directly to processes in soil because of its protecting effect.

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The Middle Cambrian Trilobite *Centropleura* in Queensland

THE trilobite genus *Centropleura* Angelin 1854 was established for a Swedish species, *Paradoxides lovéni* Angelin 1851. *Centropleura lovéni* occurs in the Middle Cambrian Andrarum limestone of Scania, Sweden. During the century that followed its first discovery, the genus was found in rocks of the same Middle Cambrian age on Bennett Island in the Arctic Ocean, in northern and eastern Siberia, in the United States in the State of Vermont, and in Canada in the eastern part of the Gaspé Peninsula. It was assumed that *Centropleura* was an 'arctic' and 'subarctic' trilobite.

In all these localities *Centropleura* is rare and is preserved as fragments unsuitable for reconstructing the exoskeleton. Angelin published a reconstruction that has been reproduced from time to time in the subsequent literature. This reconstruction is still incomplete and is, apparently, based on two different species. An almost complete specimen of a related form ("*Anopolenus*") was described from Great Britain. Although this specimen is strongly sheared, it shows an organization different from Angelin's reconstruction of *Centropleura*.

In 1952 and 1954, two species of *Centropleura* were found in Middle Cambrian sediments in Queensland, 6 and 15 miles east from Duchess. One species (the older) occurs in shale and is fragmentary. The other species occurs in limestone and is well preserved. It is slightly younger than the first and is found in the Devoncourt Limestone, the age of which is uppermost Middle Cambrian. This age is indicated by the presence of *Leiopyge laevigata* in the Limestone.

From the Devoncourt Limestone numerous fragments and a complete specimen of *Centropleura* were recovered. It is a new species closely related to the Swedish *Centropleura lovéni* (Angelin). The reconstruction of this new species is shown in Fig. 1.

The occurrence of *Centropleura* in tropical Queensland and south of the present equator disposes of the idea of an arctic trilobite with its geographical distribution controlled by climate. The scattered distribution of *Centropleura* merely indicates that the seaways were open almost the world over in Cambrian time.

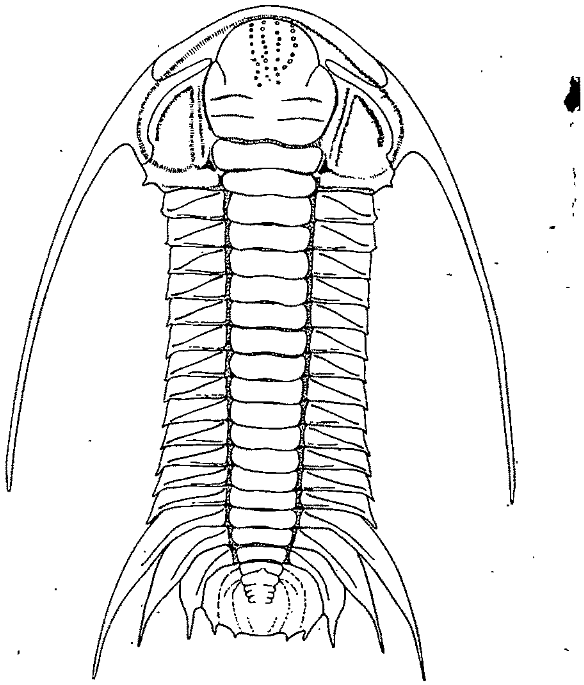

Fig. 1. *Centropleura* n.sp. (reconstruction one-third natural size); Devoncourt Limestone, Queensland

Centropleura, as seen from the reconstruction (Fig. 1), deviates in its organization from other trilobites in several ways. Its three posterior thoracic segments are macropleural and are linked with each other and with the pygidium into a rigid, non-articulating unit. This 'pygidial unit' functioned even as a moulting unit, although after moulting it could disintegrate into its four original components. The rigidity of the unit results from the backward curvature of the line of contacts between the posterior tergites, whereas flexibility along the contacts is possible only where they are straight hinge lines, as is seen between the remaining thirteen segments and the cephalon. These thirteen segments also have unusual short pleuræ with an extremely narrow doublure. The hour-glass shape of the thorax is unique.

A rostral shield fused with the hypostoma is also preserved.

Centropleura is at present assumed to be a genus of the family Paradoxididae. Its expanded glabella and the character of the posterior glabellar furrows may support this view. However, the structure of the thorax and of the pygidium, the deep interlocking of the free cheeks and cranidium, and the advanced position of the cephalic spines, including the intergenal spines, do not support the assumption of a close relationship between *Paradoxides* and *Centropleura*.

A complete description of the new species of *Centropleura* and the associated fossils is in preparation and will be published in a forthcoming bulletin of the Bureau of Mineral Resources, Geology and Geophysics.

This communication is published by permission of the Secretary, Department of National Development, Canberra, A.C.T.

A. A. ÖPIK

Bureau of Mineral Resources,
Geology and Geophysics,
Childers Street, Turner,
Canberra. May 5.

RTHCOMING EVENTS

(*Meeting marked with an asterisk * is open to the public*)

Monday, July 21

Palæontological Association (in Meeting Room J, Royal School of Mines, Prince Consort Road, London, S.W.7), at 2.30 p.m.—Prof. T. N. George: "Evolution and the Palæontological Record".

Wednesday, July 23—Wednesday, July 30

Royal Microscopical Society (at the Polytechnic School of Photography, 309 Regent Street, London, W.1)—"Micro 58": an Exhibition of Photography with the Microscope.* (July 23rd, Fellows and Invitation only.)

Thursday, July 24

Royal Society of Tropical Medicine and Hygiene (at the Hospital for Tropical Diseases, 4 St. Pancras Way, London, N.W.1), at 7.30 p.m.—Clinical Meeting. Chairman: Brigadier J. S. K. Boyd, O.B.E., F.R.S.

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer in Agricultural Economics—The Registrar, The University, Manchester 13 (July 23).

Assistant Lecturer in Physical-Organic Chemistry—The Registrar, Queen Mary College (University of London), Mile End Road, London, E.1 (July 23).

Lecturer (with a good degree in chemistry and appropriate teaching, research or industrial experience) in Spectroscopy, for duties which will include teaching spectroscopy to Diploma in technology and Degree standard and special postgraduate courses for industrial chemists—The Principal, Brunel College of Technology, Woodlands Avenue, Acton, London, W.3 (July 25).

Assistant Lecturer in the Department of Physiology—The Registrar, The University, Liverpool (July 26).

Assistant (with a first- or second-class honours degree in biochemistry or chemistry) in the Department of Biochemistry—The Secretary, The University, Edinburgh (July 26).

Engineers, Chemical Engineers or Physicists (at least 26 years of age, with a good university degree, or Corporate Member of a senior engineering institution, and preferably industrial experience), for training as Reactor Technologists—The Recruitment Officer, United Kingdom Atomic Energy Authority, Industrial Group Headquarters, Risley, Warrington, Lancashire, quoting Ref. 2476 (July 28).

Assistant Lecturer in Mathematics—The Registrar, University College of Wales, Aberystwyth (July 31).

Head of the Department of Mathematics and Physics (Grade B), Kumasi College of Technology—Council for Overseas Colleges of Arts, Science and Technology, 12 Lincoln's Inn Fields, London, W.C.2 (July 31).

Sir Alan Cobham Research Fellow in Aeronautics to carry out research in one of the following subjects: (*a*) aircraft noise and structures, (*b*) hypersonics, (*c*) helicopter vibrations, (*d*) jet flap investigations, or (*e*) numerical methods applied to wing design—The Secretary and Registrar, The University, Southampton (August 1).

Research Worker in Psychology—The Registrar, The University, Sheffield (August 2).

Demonstrator in Physiology—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (August 6).

Lecturer/Senior Lecturer (preferably with some experience in the field of aeroelasticity) in Aeronautical Engineering at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 9).

Lecturer (with a university degree in engineering or science at honours level) in Electrical Engineering at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 9).

Clinical Veterinary Pathologist (with experience in all veterinary pathological investigations) at the University of Sydney Veterinary Hospital at Camden, for duties which will include the diagnostic examination of clinical material, teaching and research—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

Lecturer (with an honours degree in physics, preferably able to teach the subject to a high standard, and with teaching, industrial or research experience) in Physics—The Principal, Wigan and District Mining and Technical College. Wigan (August 15).

Lecturers (2) in Psychology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

Senior Lecturer (with an honours degree in science) in History and Method of Science at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 15).

Research Fellow (with a Ph.D. degree in the relevant branch of chemistry with some additional experience, preferably with the Group 8 elements) in the Biological Inorganic Chemistry Unit, John Curtin School of Medical Research, Australian National University, to carry out fundamental research on the synthesis of co-ordination compounds of the heavier transitional elements—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 19).

Lecturer (with at least an honours B.Sc.) in Zoology at the University of Cape Town, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 30).

Research Assistant (with an honours degree in biochemistry or pharmacology), to work on the biochemistry of hypoglycæmic sulphonamides—The Department of Pharmacology and Therapeutics, Queen's College (University of St. Andrews), Dundee (August 30).

Lecturer (with an honours degree or a higher degree in chemical engineering or equivalent qualifications, and preferably an interest in mass transfer) in Chemical Engineering at the University of Canterbury, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

Lecturer or Senior Lecturer in History and Philosophy of Science at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August '31).

Senior Lecturer in Inorganic and Analytical Chemistry at the University of Natal, Durban—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, August 31).

Non-statutory Lecturer in Physical Chemistry—Prof. T. S. Wheeler, Department of Chemistry, University College, Dublin (September 1).

Professor of Horticulture—The Secretary and Bursar, University College, Dublin (September 1).

Reader in Fluid Mechanics at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 11).

Head (with at least a first-class honours degree in botany, agricultural botany or equivalent and preferably with suitable postgraduate research experience) of the Department of Plant Physiology—The Secretary, The Grassland Research Institute, Hurley, Near Maidenhead, Berks (September 15).

Lecturer in Pure Mathematics—The Registrar, The University, Hull (September 15).

Assistant (Grade B) to teach Chemistry with some Physics or Mathematics—The Principal, North-West Kent College of Technology, Miskin Road, Dartford, Kent.

Assistant Lecturer in Crop Husbandry, and an Assistant Lecturer in Agricultural Chemistry—The Principal, Seale Hayne Agricultural College, Newton Abbot, Devon.

Assistant Lecturer in Mathematics—The Secretary, The Royal College of Science and Technology, Glasgow.

Experimental Officer (not under 26 years of age, with at least H.S.C. (Science) or equivalent and extensive experience in metallurgical analysis, including the analysis and control of trade waste effluent, and preferably several years supervisory experience), to be responsible to the Laboratory Manager for the work of a small team engaged on general inorganic chemical analysis—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting Ref. A/1736/34.

Lecturer/Demonstrator in the Chemistry Department—The Bursar, Royal Agricultural College, Cirencester.

Reader (with a degree of a British university and research qualifications in some branch of applied mathematics or statistics) in Applied Mathematics—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Research Students in Organic and Inorganic Chemistry—The Secretary and Registrar, The University, Southampton.

Scientific Officer (with a first- or second-class honours degree in mathematics, science or economics) at the Building Research Station (D.S.I.R.), Garston, Watford, for work in a section dealing with information and publicity through exhibitions, press, etc., secretarial work for home and European scientific committees, patents, and general central administration on scientific matters—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.242/8A.

Senior Lecturer or Lecturer in the Department of Aerodynamics, for lecturing to, and supervising work of, postgraduate students in the field of stability and control—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Anti-Locust Bulletin No. 30: Oviposition Behaviour and Egg Mortality of the Desert Locust (*Schistocerca gregaria* Forskål) on the Coast of Eritrea. By W. J. Stower, G. B. Popov and D. J. Greathead. Pp. 33+17 figures. (London: Anti-Locust Research Centre, 1958.) 7*s*. [195

Planning, Vol. 24, No. 422 (19 May, 1958): The Price of Stability. Pp. 89–108. (London: Political and Economic Planning, 1958.) 2*s*. 6*d*. [195

Rowett Research Institute. Collected Papers, Vol. 14. 94 Papers. Collected Papers, Vol. 14: Summary and Subject Reviews. Pp. ii+54. (Bucksburn, Aberdeenshire: Rowett Research Institute, 1958.) [195

Interdepartmental Committee on Social and Economic Research. Guides to Official Sources, No. 4: Agricultural and Food Statistics. Pp. vi+71. (London: H.M. Stationery Office, 1958). 4*s*. 6*d*. net [225

Department of Scientific and Industrial Research: Building Research Station. National Building Studies: Special Report No. 26: Simplified Daylight Tables: Tables for the Quick Estimating of Direct and Indirect Daylight in Buildings Lit by Vertically Glazed Windows. By Dr. R. G. Hopkinson, J. Longmore and A. Murray Graham. Pp. iv+24. (London: H.M. Stationery Office, 1958.) 1*s*. 9*d*. net. [225

The Modern Florilegium: a List of Special Plants chosen for Garden Economy and Flower Arrangement. Compiled by G. S. Thomas. Pp. 80 (23 photographs). (Windlesham, Surrey: Sunningdale Nurseries, 1958.) 3*s*. [225

Ministry of Agriculture, Fisheries and Food. Crop Protection Products Approval Scheme: Approved List, 1958. Pp. 66. (London: Ministry of Agriculture, Fisheries and Food, 1958.) [225

British Iron and Steel Research Association. Annual Report, 1957. Pp. 140. (London: British Iron and Steel Research Association, (1958.) [225

Reports to the Worshipful Company of Clothworkers of the City of London of the Advisory Committee on the Departments of Textile Industries and Colour Chemistry and Dyeing in the University of Leeds. Session 1954–55. Pp. 46. Session 1955–56. Pp. 46. Session 1956–57. Pp. 47. (Leeds: The University.) [225

National Institute of Oceanography. Collected Reprints, Vol. 5. Reprints Nos. 163–209. (Wormley, near Godalming: National Institute of Oceanography, 1957.) [225

The Humane Killing of Crabs and Lobsters. Pp. 8. (London: Universities Federation for Animal Welfare, 1958.) [225

Association of University Teachers. Report on a Policy for University Expansion. Pp. 14. (London: Association of University Teachers, 1958.) 3*s*. [225

Span, No. 1 (April, 1958). (Shell Public Health and Agricultural News.) Pp. 32. Published quarterly. (London: Shell Petroleum Co., Ltd., 1958.) [225

Committee of the Privy Council for Agricultural Research. Report of the Agricultural Research Council for the year 1956–57. Pp. iv+152. (Cmnd. 432.) (London: H.M. Stationery Office, 1958.) 7*s*. net. [235

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1957. Durham Division. By W. Brown. Pp. iv+34. 2*s*. 6*d*. net. South Western Division. By T. A. Jones, O.B.E. Pp. iv+28+4 plates. 2*s*. 6*d*. net. (London: H.M. Stationery Office, 1958.) [235

Report of the Rugby School Natural History Society for the year 1957. Pp. 28+1 plate. (Ninety-fifth issue.) (Rugby: Rugby School Natural History Society, 1958.) [235

British Medical Bulletin, Vol. 14, No. 2 (May, 1958): Causation of Cancer. Pp. 73–196+4 plates. (London: British Council, 1958.) 25*s*. [235

Philosophical Transactions of the Royal Society of London. Series B: Biological Sciences. No. 682, Vol. 241 (22 May, 1958): The Pleistocene Geology and Geomorphology of Three Gaps in the Midland Jurassic Escarpment. By W. W. Bishop. Pp. 255–306. (London: Royal Society, 1958.) 16*s*. 6*d*. [235

Lundy Field Society. Eleventh Annual Report, 1957. Pp. 43+2 plates. (Exeter: Prof. L. A. Harvey (Secretary), c/o The University, 1958.) [275

Scottish Field Studies Association. Annual Report including Accounts and Balance Sheet for the year 1957. Pp. 11. (Glasgow: Scottish Field Studies Association, Department of Botany, The University, 1958.) [275

University of Reading: Museum of English Rural Life. Report for 1957. Pp. 16. (Reading: The University, 1958.) 1*s*. [285

Discovery Reports, Vol. 29. Pp. 199–228+plate 10: The Distribution of the Chaetognatha of the Southern Ocean. By P. M. David. (Cambridge: At the University Press, 1958. Issued by the National Institute of Oceanography.) 18*s*. 6*d*. net. [295

Department of Scientific and Industrial Research. Mechanical Engineering Research 1957: Report of the Mechanical Engineering Research Board, with the Report of the Director of Mechanical Engineering Research. Pp. iv+63+4 plates. (London: H.M. Stationery Office, 1958.) 4*s*. 6*d*. net. [295

Institution of Gas Engineers. Publication No. 520: 95th Annual Report and Accounts of the Council of the Institution of Gas Engineers to be presented at the 95th Annual General Meeting, London, 13th to 16th May, 1958. Pp. 46. Publication No. 521: Presidential Address. By Dr. J. Burns. Pp. 38. Publication No. 522: Materials and Structures. By S. V. Gardner. Pp. 77. Publication No. 523: The Sulphur Impurity in Town Gas. By L. J. Clark and Dr. E. Spivey. Pp. 23. Publication No. 524: Sulphur and Gas Appliances. By C. H. Purkis. Pp. 38. Publication No. 525: Actions, Reactions, and Side Reactions of Catalytic Sulphur Removal. By W. Wedgwood. Pp. 29. Publication No. 526: Domestic Marketing: Comment and Conjecture. By J. A. Buckley. Publication No. 527: Utilization Efficiency of Industrial Gas Appliances. By E. A. K. Patrick. Pp. 24. Publication No. 528: By-Products in the Economy of Gas Manufacture. By L. W. Blundell. Pp. 48. Publication No. 529: Work Study: Three Years' Progress at Edinburgh. By David Beavis. Pp. 35. Publication No. 530: Official Programme—95th Annual General Meeting, London, 13th–16th May, 1958. Pp. 12. (London: Institution of Gas Engineers, 1958.) [295

Other Countries

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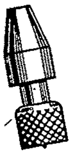

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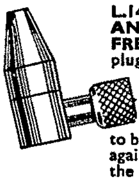

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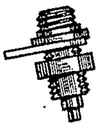

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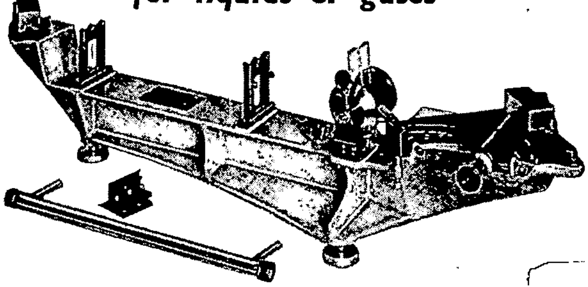

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THE STRUCTURE OF RESEARCH IN BRITAIN

IN an address on the role of government in science at the annual dinner of the Institute of Physics on March 26, Lord Hailsham expressed the opinion that many of the thorniest problems of political life would be dealt with in a more wholesome and practical way if solved by the pragmatic sanctions of technical requirements than if pursued as a doctrinal issue by *a priori* argument. While without Government support much essential scientific work would no doubt remain undone, the role of Government in science is inevitably unsatisfactory because science, a subject beyond all else jealous of its integrity, must pursue its courses without political interference.

The main theme of his address was the necessity for a close partnership between Government and science, and in discussing this question Lord Hailsham affirmed his belief that, although the risk of waste is always present in research, neither in fundamental nor in applied research are we in Britain, as a nation or as individuals, in danger of spending too much. Speaking as Lord President of the Council, Lord Hailsham claimed that the system of research councils under the Lord President places civil research in the hands of scientists themselves, and Government responsibility is discharged largely by patronage, in the old and good sense of the word, by interest, co-ordination and, to some extent, by initiative, vision and enterprise. Lord Hailsham recognized very clearly that the selection of the right projects and the decision when to extend, continue or to terminate them are the crucial problems in research, and that they demand a constant influx of young and active minds. He stressed, too, the significance of appropriate conditions if research is to be an attractive career; and he mentioned also the importance of egress as well as entry, and the value of constant cross-fertilization between research institutions and user and teaching bodies.

Lord Hailsham did not comment on the adequacy or otherwise of the Government contribution of some £225 million to the national expenditure of £300 million annually on research; he said he is convinced that, viewing scientific research simply as an investment, the industrial and private contribution could with advantage be considerably increased. He also believes that too little use is made of the published results of research. On the whole, Lord Hailsham thinks we have achieved the right balance in our administration or control of research; but, in a concluding reference to the industrial research associations, he appealed for greater interest in them by the industries they serve, and for the co-operation of the trades unions. Coupled with the indication in the subsequent report of the Council for Scientific and Industrial Research that Government policy in regard to the research associations is under review, although the Council has not yet reached final conclusions, and with some criticism of the electrical industry which Lord Hailsham made on another occasion, this has led to some speculation as to whether the Government is minded to wind up the research associations.

There are large issues involved in any such policy; but apart from this, Lord Hailsham's complacency scarcely seems justified in the light of the recent report of the Research Council (see *Nature*, June 14, p. 1623). Moreover, Dr. G. B. B. M. Sutherland's remarks as an introduction to the annual open days at the National Physical Laboratory suggest doubts as to whether, in fact, we have achieved the right balance in the organization and control of research. Dr. Sutherland emphasized the potentialities of the Government research stations, which, when well led, can and should be a jump ahead of industry. He claimed that the value of the work at the National Physical Laboratory to the national economy is at least as great as that of Harwell, but he was obviously dissatisfied with the way in which Government control is exerted. Few research projects have been terminated for lack of money, but it would appear that Treasury control has been exercised in such a way as to infringe the independence or integrity of science, which Lord Hailsham recognizes as of such outstanding importance.

In contrast to Lord Hailsham, Sir Hugh Beaver, a former chairman of the Advisory Council for Scientific and Industrial Research, in his presidential address to the Institution of Chemical Engineers on April 30, was frankly critical of the adequacy of present arrangements in Britain to make full use of the resources of science in the service of the State. Sir Hugh was concerned in this address mainly with the educational aspect and with the financing and organization of research, though he touched very briefly on the question of seeing that the results of research are both known and applied, and also on the assistance of development. The key problem is that of education, and here he showed convincingly that there is, in fact, no national policy to produce an adequate supply of scientists and technologists, or even the national organization to secure an educational policy. Even more impressive, coming from a former chairman of the Advisory Council, is the criticism of the Government structure for the organization of research, and particularly of the Department of Scientific and Industrial Research. Sir Hugh asserted that the bulk of Government research or of research sponsored by the Government does not come under the Lord President at all. Besides defence research and that on nuclear energy under the Atomic Energy Authority, any Government finance for the aircraft industry will presumably continue to come through the Ministry of Transport and Civil Aviation or the Ministry of Supply, and important research is carried out under the Ministry of Power; while the contribution of the Department of Scientific and Industrial Research to research in the universities of Britain, the recognized home of fundamental research, now runs at half a million pounds annually, with grants to students—which might be taken as contributing something to that purpose—exceeding £800,000, compared with a recurrent grant of about £50 million provided through the University Grants Committee.

The activities of the National Research Development Corporation and of the Patent Office seem ancillary to research rather than a part of the national research effort, but in noting that the work of those bodies comes under the Board of Trade, Sir Hugh Beaver was really directing attention to the way in which responsibility for the scientific effort of the nation is distributed over numerous departments, and that the tendency to regard the Lord President as an approximation to a Minister for Science is misleading and ill-conceived. His point that no means exist either for formulating or securing a co-ordinated national policy of research or for directing the many research activities in Britain to desired ends is incontestable, and it tends to be concealed when the Lord President is made the spokesman for the scientific activities of the Government generally, even if indirectly. Further, Sir Hugh, pointing out that the Department of Scientific and Industrial Research could be described as largely a common service research department for other Government departments, remarked that there is still a wide division of opinion as to whether the various Ministries should have their own research departments or depend on the Department of Scientific and Industrial Research. The Select Committee on Estimates has sometimes been severely critical of departmental research, but the question still seems to be unresolved.

Finally, Sir Hugh Beaver suggested that by its organization the Department of Scientific and Industrial Research is virtually without a ministerial head. He did not advance any constructive suggestions here, and although his words seem to imply that the Department should be given wider responsibilities for research, he questioned whether the recent changes have made the Department suitable in form and in methods for discharging duties which its title envisages. He does not think that the Lord President of the Council is in the appropriate position to direct the scientific thinking and planning which we need to formulate a coherent policy capable of handling all the four aspects involved, namely: education, or the production of the scientists and scientific leaders; the encouragement and support of research and the allocation of research workers; the dissemination and application of the results of research; and the problems of finance. Nor does he favour the idea of a Minister of Science with such over-riding powers as the Minister of Defence possesses, even if to some extent such a Ministry would be consistent with the present position of the Ministry of Defence.

Neither Sir Hugh Beaver's address nor Lord Hailsham's speech takes us as close to the root of the matter as the discussion of scientific research in the recent survey of the organization of British central government made by a Study Group of the Royal Institute of Public Administrators, or Lord Waverley in his Romanes Lecture of 1946. Both are of value, however, as indicating certain aspects which the Council of Scientific and Industrial Research should have in mind in the survey of the work of the Department on which it is now engaged. The limitations to which Sir Hugh has directed attention should not affect the Council's consideration of the contribution of the Department to fundamental research, or the part which its own stations can play in industrial and applied research. For all those limitations, the Department is in a position to bring a wider perspective to bear than most other organizations, and to make a significant contribution towards redressing the balance of effort and avoiding duplication and waste. Moreover, Sir Hugh did not show why the responsibilities of the Lord President should not be extended in the field of science and less relevant duties curtailed, particularly if the Office were adequately and appropriately staffed.

It is clearly desirable that some means should be found for improving on the present haphazard and illogical manner in which the Government attempts to discharge its responsibilities towards science, though a completely formal and unified structure may not be the right answer. It is important, however, that, while inquiry and fresh thought as to the best and most appropriate means for ministerial responsibility and guidance to be exercised proceeds, care should be taken not to endanger the advantages which the present arrangements possess. Among those advantages the functions of the Department, in respect of both university awards and research grants and also the industrial research association system, are outstanding. However much direction at ministerial level may be improved, the value of such an independent stream of research grants will remain, and it would become even more difficult to correct weaknesses or to meet some recognized needs in university research if all Government grants for such purposes flowed to the universities in a single stream. It should be noted that the recent report of the U.S. National Science Foundation on the relations between central government and universities strongly emphasized the value of a diversity of government sources of support for university and fundamental research.

Again, while the industrial research association may not be the appropriate arrangement for every industry, and indeed in some circumstances could, by its very success, make a research association in a particular industry no longer necessary, it has become clear that the research associations in Britain are also performing very useful educational functions, quite apart from their work in furthering the dissemination of the results of research and stimulating its application. It is true that, in respect of applied research, the research association is at an inherent disadvantage compared with the research department of an individual firm; but in almost every industry there are likely to be projects which are most economically and efficiently tackled by co-operative effort. Such factors require close consideration in determining the future of the industrial research associations, and their contribution to technical and technological education must be carefully weighed in considering the supply of scientists, technologists and technicians and the educational policy required to produce them.

It is essential, therefore, that the Council for Scientific and Industrial Research should formulate very clearly its ideas as to the exact functions of the research associations and of the Department's own research stations and institutions, and that their advantages and disadvantages should be fully discussed before any decisive change is made in the present system. It is by the appropriate use of a wide range of types of institution rather than by a rigid and formal structure that weaknesses in research are best corrected, and while it is important that every effort should be made to see that these institutions are as efficient as possible and appropriately used, it should not be forgotten that success primarily depends upon men.

This point was made by Prof. R. S. Nyholm in a recent broadcast on university research and its financial needs. After stressing the desirability of varied sources of finance, and particularly the desirability of sources of finance over and above that received from industrial organizations and research institutions, in which he referred to the value of the help received from the Department of Scientific and Industrial Research, Prof. Nyholm said that he is convinced that unless we put a much greater effort into fundamental research Britain will face serious problems in a few years time, because our position in the world twenty years hence would be determined by the fundamental research of to-day. Prof. Nyholm was particularly concerned with the calibre of the scientists whom we are losing to the United States and to other countries, partly at least because the opportunities for fundamental research, the equipment and the salaries offered are better than in Britain.

Prof. Nyholm was discussing primarily the financial aspect ; but he believes that Britain can hold its best people and still attract the best from abroad if it will continue to lay emphasis upon that most precious privilege of the university, namely, freedom to do what one likes—which implies to-day the finance with which to do it. Lord Hailsham seemed to recognize this ; but while the appropriateness of our whole structure for research receives examination and the relations of the different types of research institution are being reconsidered, there is much the Government could do to promote the conditions which will attract the ablest minds into research and enable them to give of their best. Nor is it simply a matter of attracting the scientist or technologist into research ; it is equally important, as Sir Hugh Beaver noted, to produce scientific leaders.

This is a matter to which post-war Governments in Britain, whatever their political party, and however they may have professed their concern with the supply of scientists and technologists and their support of research, have in practice been consistently indifferent. Mr. Stanley Mayne's address to the delegate conference of the Institution of Professional Civil Servants on May 19 recapitulated some recent instances of the way in which lack of vision, clear purpose and vigorous resolution are cramping and devitalizing the scientific development of Britain. To his catalogue of examples, including the failure to make use of the Royal Ordnance factories, difficulties in connexion with aeronautical research, university finance and railway transport, and the failure of the Atomic Energy Authority to intensify recruiting and build up staff in accordance with recommendations of the Fleck Committee, could be added others, notably in the parsimony displayed towards the National Science Centre and all the projects for developing an adequate system of national lending and references libraries for science and technology.

All this obviously arises from the failure on the part of Government to appreciate the bearing of such factors on the effectiveness with which scientific work is carried out and the efficiency with which its results are made known and applied. Until genuine attention is given at Cabinet-level to the effect of society on science, the way in which obsolete forms of organization, lack of knowledge, political prejudice and the like frustrate the use of science and the development of technology, changes in the organization of the means of central direction are likely to have little effect. Decisive action by Cabinet Ministers who really understand the significance of science and technology and the conditions in which good work is done most effectively would go far to remove many of the existing hindrances, and to promote more effective use of trained man-power and other scientific and technical resources. To such matters as scientific and technical libraries might be added the control of the Patent Office, the taxation of learned societies, tax allowances for books, and questions of postage and publication, all of which can influence decisively the efficiency of communication. Such matters require no fresh forms of organization but merely people at Cabinet-level able to comprehend the issues and resolute to take the necessary action.

It is once again a matter of education, ultimately long-term but requiring also a short-term effort, if Britain is to have any real prospect of developing her scientific and technological potential. The recent report from the Council of Scientific and Industrial Research suggests that important issues of the organization and structure of research have already been raised in the Council's relation to the Agricultural Research Council and the Medical Research Council ; and the Minister of Supply's recent statement on aircraft research indicates another direction in which the question of structure has assumed fresh importance. So, too, in the field of nuclear research, where not only Sir Hugh Beaver's address but also recent addresses on the development of the industry accentuate the importance of achieving an appropriate balance in the use of man-power and materials for research, and suggest doubts as to whether in fact the Council for Scientific and Industrial Research is the appropriate body to establish that balance.

Sir Hugh Beaver has rightly directed attention to weaknesses in our structure for research which merit fresh inquiry and constructive thought as a matter of urgency. Even more important, he has emphasized the close relation of the whole question of research, its organization and the provision made for its pursuit with that of education, not simply for the production of scientists and technologists, or even of the supporting technicians, upon whom the efficient use of highly trained man-power largely depends, but also of educational policy as a whole—a policy which is concerned both to produce scientists and technologists and the citizens and administrators capable of appreciating and supporting their work. The unity of education and research in relation to science and technology could not be better put. Imperative as it may be to devise appropriate arrangements for providing effective scientific and technical advice at all levels, from the Cabinet downwards, to make the fullest possible and most appropriate use of the wide range of research institutions at our disposal, to further efficient co-operation between government departments, industry, the universities and other independent research institutions, and the professional organizations of scientists and technologists, the key problem is that of education. The promotion of the expansion of scientific, technological and technical education is not enough by itself; it must be accompanied by the development of an educational system and policy which will equip men and women to live in this technological age, and will produce not simply the essential specialists but also leaders, from ministerial level downwards, aware of the human as well as the technical issues and capable of the vision and the resolution required to make full and wise use of the powers now at the command of mankind.

ADVANCES IN NUCLEAR ENGINEERING

Advances in Nuclear Engineering

Proceedings of the Second Nuclear Engineering and Science Conference held at Philadelphia. Edited by John R. Dunning and Brice R. Prentice. Vol. 1: Pp. vii+523. Vol. 2: Pp. vii+581. (London and New York: Pergamon Press, 1957.) 147*s*. net each volume.

THE International Congress on Atomic Energy held in Geneva, 1955, opened the door, closed for fifteen years, to scientific and technical information about fission and nuclear reactors. In spite of the 1,000 papers published then, there was an enormous amount of material not presented at that time, and, of course, since that time technology has proceeded apace in the many branches of applied science embraced within nuclear engineering. These volumes record the proceedings of the Second Nuclear Engineering and Science Conference held in Philadelphia, March 1957, and comprise 130 papers on reactors, fuel and a few other matters, almost all the papers being of American origin. Many of the papers amplify the Geneva subjects—such as details of the Hanford waste disposal, recovery of uranium from the Oak Ridge diffusion plant, plutonium extraction plant, etc.; many more take us forward from Geneva, such as the consideration of irradiation of liquid bismuth containing uranium, consideration of containment vessels, and the analysis of safety standards to be adopted in ships carrying reactors.

Vol. 1 opens with two papers which are interesting to read a year after they were written. A member of the U.S. Atomic Energy Commission, referring to the British nuclear energy programme based on an average cost figure of 350–400 dollars per installed kW. for the complete power stations being built by industry, remarked that these figures appeared to be materially higher than those estimated for the Yankee pressurized water reactor; alas, only in October, at the Twelfth American Assembly, the cost of the Yankee station is estimated to be more than 550 dollars/kW., and that may not include the complete power station (the Shippingport 60-MW. reactor appears to cost 1,000 dollars/kW. for the reactor portion alone). The speaker also expressed satisfaction over the fact that America had more export orders for research reactors than any other country; but is it hard to sell such reactors if the sale also includes the gift of the whole or half of the cost of uranium-235? One of the "Three Wise Men" wisely said at the Conference, "Again, Europe needs your help, but . . . our relationship will not be that of one country giving and another receiving, but of two great united nations (the U.S.A. and U.S. Europe) working in association".

Vol. 1 contains many papers on the refining of fuels, processing after irradiation, and economic consideration of fuel cycles. Some papers concern experience with the technology of reactors already in operation, others deal with the projected reactors, such as the thorium/uranium breeder reactor, the continuous removal of fission products from molten bismuth containing 0·1 per cent fuel, and a speculative paper on the economics of ceramic fuel elements operated at temperatures far higher than any fuel in operation to-day. There are many papers on pressure vessels, and pipes and other components which have to withstand high pressures or contain molten sodium, and a fairly detailed paper on the Enrico Fermi 100-MW. fast breeder reactor now being built to operate at 880° F. Almost all the large reactors now being built in America will be surrounded by a steel containment vessel of the order of 200 ft. in diameter for which there is at present no design code, and the section on plant containment is full of important information.

There is a long section on the disposal of radioactive wastes. No method now exists, says one writer, which is both cheap and permanently satisfactory. Fixation of fission products in clay is attractive, but over long periods of time it is difficult to predict the probability of water reaching the burial ground of the clay, and leaching out the long-lived elements. A Canadian paper reports some success in fixing wastes in a lime glass which would then be buried in dry ground—adding 0·1 mil/kWh. to the cost of electricity. The facilities for dealing with the wastes from the Shippingport reactor are described; here the water becomes radioactive due to corrosion and at times of maintenance is removed from the reactor but may not be dumped into the Ohio River. Ion exchange resins have been chosen, and the solution is regarded as satisfactory, simple and economical: the resin reduces non-volatile radioactivity by a factor of 1,000 and a 'gas-phase stripper' removes activity of a further 10^6. Active resins are then stored presumably in perpetuity. Anticipated costs are not given for this treatment, although in a companion paper the capital costs are spoken of as being high.

In the section on protection and safety measures there are two papers which should be read carefully by people having responsibility for health measures in atomic plants; they concern the three basic standards of maximum permissible exposure, the last of which, dealing with total absorbed dose up to age thirty and thereafter, has only been adopted in the past year. The effect of this third recommendation is effectively to reduce the average occupational dose-rate by a further factor of 3, now to 0·1 rem/week. Dr. Lauriston Taylor's article carefully analyses the effect of these new levels on radiation control problems. An analysis of the hazards of the application of nuclear power for ship propulsion seems to show that these are distinctly greater than will be encountered with land-based stations; from a safety point of view the ship power plant ought to use low-pressure coolant, but all the submarines so far employ the pressurized water reactors operating at thousands of pounds per square inch pressure. The writer does not favour the gas-cooled reactor "when the power plant is mobile and open to collisions".

The provision of facilities for irradiating food is discussed in several papers, although no new major advance is reported on the art or science of food processing. The U.S. Army is sponsoring both electron accelerators and a γ-source (a reactor) to support research on the subject, and Brookhaven has designed a cobalt irradiator of high power. There is an interesting description of the medical research programme using the Brookhaven research reactor; the article concludes with the remark that the irradiation of diseased sites in which elements having high neutron affinity have been selectively absorbed is one of the most important uses of the reactor and is expected to remain so for a long time to come.

In Vol. 2 will be found important engineering papers on problems of some of the large power reactors such as the 175-MW. engineering test reactor at Idaho, the 20-MW. sodium-cooled reactor, the Oak Ridge homogeneous reactor which has exhibited extensive stress corrosion cracks in austenitic steel tubing and flanges, the 60-MW. breeder reactor (EBR 2) for which performance tests on individual items of construction are quoted, and the pressurized water reactors for which a considerable body of operating experience now exists. Some remarkable results on the behaviour of suspensions of uranium oxide in liquid metals are given for the first time, and there is more information on the polyphenols as possible coolants for power reactors. There are many papers on research reactors; several of our university reactor courses have fully realized the importance of instruction being given at the reactor face, and the Oak Ridge School of Reactor Technology, which has had more experience of reactor teaching than anywhere else in America, firmly advocates such teaching supplemented with reactor experimentation. In these papers will be found accounts of many experiments which can be formed on quite low-powered reactors.

There are many papers on the metallurgy of reactor constructional materials and fuels, pure and alloyed. Some results of neutron irradiation of common pure metals—non-fissionable—do not agree with Russian work reported at Geneva. The metals investigated in the Materials Testing Reactor (MTR) for three weeks hardened but did not exhibit changes in microstructure. Hanford metallurgists report on the mechanical properties of uranium after irradiation at various temperatures; the results indicate the extreme importance of optimum design of fuel elements if trouble due to distortion is to be avoided. The mechanical and anti-corrosion properties of uranium alloys with small additions of molybdenum and other elements together with ternary elements have been studied in many laboratories, but unfortunately no work is presented on irradiation damage to these alloys with the exception of one paper on pressed powder compacts of uranium and of a few of its simple alloys. It is interesting to note that even hot-pressed compacts considered at the time of Geneva to be randomly oriented have now, however, been shown to be sufficiently oriented to develop substantial dimensional changes upon irradiation, and the sintered alloy compacts swell as fast as, or faster than, unalloyed specimens. The general conclusion of several authors at the Conference was that much more work on alloys at high burn-up should be done before the best of them can be applied to reactor design.

Reactor instrumentation is a very important subject considered by one section of the Conference. One paper suggests that reactor instrumentation can now be regarded as conventional, needing only to be matched with the requirements of the reactor, but in general the papers show that many new instruments are being developed to cover a wide range of measurements. Even the common resistance thermometer has been given a new look to withstand 5,000 lb./in.^{2} for use in the pressurized water reactors. An ultrasonic flowmeter with an output signal independent of temperature of either water or of hydrocarbon fluid is one of the most original instruments described, and there are important contributions to neutron flux and positron life-time measurement. There is a strong plea put in for standardization of instruments in such a way as not to stultify the development of them, but no indication is given of what has been achieved by way of standardization to date.

The volumes are very well produced and all figures are adequate. The achievement of publication within six months of the Conference is commendable, especially as the volumes are printed and not produced by one of the modern off-set methods. The Conference has not made the mistake which I consider was made by the 1955 Geneva Congress—that of publishing the author's spoken presentation of the paper in addition to the paper, and the discussion which followed.

T. E. ALLIBONE

ANATOMY OF MATHEMATICS

A History of Mathematics

From Antiquity to the Beginning of the Nineteenth Century. By Dr. J. F. Scott. Pp. xii+266+6 plates. (London: Taylor and Francis, Ltd., 1958.) 63*s*. net.

A HISTORY of mathematics up to A.D. 1800 in 216 pages of main text can scarcely be more than an epitome. Dr. Scott spares us the trivial if amusing gossip about personalities, and concentrates on tracing the lines of development of the subject; an appendix contains brief biographical notes on some 120 great mathematicians. But even so, there is little enough room for a comprehensive account. Dr. Scott's earlier studies have been chiefly concerned with the seventeenth century, and in his book this century occupies one-third of the main text. Consequently, some other periods receive sketchy treatment: the eighteenth century is given very little of the detailed discussion of method accorded to the previous century. If it is argued that the eighteenth century mathematicians merely exploited the creative ideas of their predecessors, the book might well have ended with the death of Newton.

The Greek period is given generous space. Dr. Scott's estimates of the debts the Greeks owed to the Egyptians and the Babylonians would not be universally accepted, and the general reader might well consult van der Waerden, "Science Awakening", for the somewhat different view presented by that great Dutch mathematician. On Greek mathematics itself, there is much useful and clear description, with comments that are sometimes misleading. For example, to remark of the parallel postulate, "It is not that anyone questions the truth of it: the important point is that it is not self-evident, as an axiom should be", after saying that "alternative geometries could be devised in which this postulate plays no part", may cause the unwary reader to suppose that non-Euclidean geometries are false. Moreover, this comment ignores the distinction drawn by the Greeks between the axiom or 'common notion' and the postulate or special assumption, which the student is asked to grant, not to accept as a 'self-evident truth'. Again, we are told that Archimedes had no idea of proceeding to a limit, but argued that if an area did not have measure k, then a contradiction must follow; this obscures the fact that for this argument to work, we must first know k, and it seems likely that Archimedes sometimes obtained k by a limit process, which was then suppressed in writing out the final synthetic demonstration.

It is with the seventeenth century that Dr. Scott gets into his full stride. His enthusiasm for the great mathematicians of that era, his wide knowledge of the material, his careful description of methods combine to provide an account which at times gives a sense of the excitement of discovery. Napier's logarithms, Descartes' marriage of algebra with geometry, Newton's binomial theorem are all most attractively described. The futile controversy between Newton and Leibniz over the invention of the calculus is briefly dismissed with the sensible remark that there is no sound reason against believing the discovery to have been made independently and more or less simultaneously. But the author is perhaps a little too generous to the forerunners, Cavalieri, Fermat, Barrow, and others; the step from their knowledge to that of Newton and Leibniz is more critical than Dr. Scott allows, and reference for a lucid and precise discussion of this point may be made to an article by Hadamard in the Royal Society's volume, "Newton Tercentenary Celebrations".

There are some excellent plates: the Rhind papyrus, pages from Barrow's "Euclid", Oughtred's "Clavis" and Stevin's "Statique", and two pages of the famous letter in which Newton describes the steps which led him to the discovery of the binomial theorem.

T. A. A. Broadbent

THE PROVINCE OF LOGIC

The Uses of Argument

By Prof. Stephen Edelston Toulmin. Pp. vii+261. (Cambridge: At the University Press, 1958.) 22*s*. 6*d*. net.

This book contains an interesting and provocative discussion of the philosophical issues about the nature of logic. Toulmin considers that logic traditionally has as a main object the study of argument; but, he maintains, logic has tended more and more to become a mathematical discipline the relevance of which to an understanding of the principles of argument is hard to discern. The root cause of this partial failure of logic is diagnosed as an excessive regard for the analytical type of argument found in pure mathematics combined with a desire that logic itself should have formal rigour. Logicians, therefore, have failed to see, or have neglected, the fact that most of our arguments, scientific, moral or legal, are not of this analytical type and cannot be judged valid or invalid, convincing or unconvincing, by the same criteria of logical evaluation as are the analytical arguments of mathematics. Such terms as 'valid', Toulmin holds, are general terms of evaluation, the criteria for the application of which vary systematically according to the type of argument under consideration; but formal logic has been so preoccupied with analytical argument that the criteria for the application of evaluative terms of logic to analytical arguments have been taken to be the unvarying meaning of those terms in all contexts. Toulmin considers that if we are to throw light on the nature of argument we must clearly recognize that different criteria of logical merit apply to different kinds of argument and seek to bring these criteria to light by a study of actual argument.

In his second chapter Toulmin gives an extended specimen of the kind of study of argument that he is advocating by an examination of the notion of probability. He argues very plausibly that the attempts of Carnap and Kneale to analyse the concept of probability against the background of the traditional approach to logic are unsuccessful; then, making use of a valuable distinction between improprieties and mistakes in assertions, he maintains the thesis that to say 'probably p' is to assert p (with the consequent risk of being mistaken) but to assert p *guardedly*, as is appropriate when grounds for assertion are weak, thus evading the impropriety of bald assertion in such circumstances. Toulmin maintains that this interpretation of probability is applicable even in such contexts as seem most favourable to a frequency interpretation; but it is hard to see that "The probability of throwing heads is $\frac{1}{2}$" is a guarded statement, or, if it is, what form of words one would use to make the same statement in an unguarded way.

Toulmin also offers a new schematism for the description of arguments. He recommends us to think of data, warrant and conclusion rather than of premisses and conclusion. Thus we could say that from the datum that Socrates is a man we conclude that Socrates is mortal with "All men are mortal" as our warrant; or we may conclude that Petersen is probably not a Roman Catholic from the datum that he is a Swede, with "Few Swedes are Roman Catholics" as our warrant. Toulmin argues persuasively in favour of some such redescription of argument; but it is not entirely clear what this distinction between a warrant and a datum is: How would one know which of two universal premisses in a syllogism was datum and which warrant?

With modesty Toulmin claims to have raised problems rather than to have solved them. Anyone with an interest in the study of argument in real life, not merely in formal logicians' theorems, will find here much to interest him, something to convince him and, in all probability, something to provoke him to argument.

J. O. Urmson

SUBMICROSCOPIC MORPHOLOGY

Macromolecules in Cell Structure

By Prof. A. Frey-Wyssling. (The John M. Prather Lectures, 1956.) Pp. vii+112+13 plates. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1957.) 40*s.* net.

THERE is evidence that the Prather Lectures on which this book is based were actually delivered at Harvard in 1955, which, in a subject that is advancing so rapidly, detracts a little from a presentation in 1957, but it will none the less be warmly welcomed by the numerous admirers of Prof. A. Frey-Wyssling's pioneer researches and earlier contributions to the literature. It is a handsome little book, and the electron micrographs especially, on which so much of the argument depends, are very well reproduced.

The emphasis and the topics chosen are naturally mostly botanical—the fine-structure of starch grains and chloroplasts, and the fine-structure, growth, and differentiation of plant-cell walls—but a necessary wider background also is provided by a chapter on "Macromolecules in the Cytoplasm". The approach throughout, as is to be expected in a set of special lectures of this kind, is distinctly personal, and this extends to many of the references and some of the text-figures. For example (p. 1): "I have called this new field of investigation *Submicroscopic morphology*. In the early days we used polarizing microscopy for this research (Ambronn and Frey, 1926), but soon X-ray diffractometry brought welcome support (Frey-Wyssling 1937*a*), and since 1944 electron microscopy (Frey-Wyssling and Mühlethaler 1944, 1946) has raised submicroscopic morphology to a generally recognised standard science". Such historical over-condensations are in the cause of saving space, but newcomers might misconstrue them, I am afraid.

Though Prof. Frey-Wyssling's favoured technique these days is electron microscopy, of which he has made most valuable use, he concedes that the older methods of polarizing microscopy and X-ray analysis are "still useful" (p. 5), and indeed ranges over and seeks to co-ordinate all kinds of information, as the reader will find to his ever-widening profit. There is no narrow way of looking at the structure of biological tissues, and no shallow way either. We continue uncovering finer and finer constituents, but the picture appears still much the same in the depths. Prof. Frey-Wyssling makes this point repeatedly, as when, for example, he remarks, "this special architecture must be the result of the morphogenetic work of the cytoplasm. Mere mechanical considerations cannot explain the inception of any differentiation" (p. 36); and "The bordered pits are a beautiful example of the morphogenetic capacity of the cytoplasm" (p. 48); and as regards the cytoplasm itself, so optically empty no longer ago than the early 'thirties, I particularly like his summarizing comment: "As a result of this discussion we find that the term cytoplasm is defined by the negative property of comprising that fraction of the living substance that escapes our morphological analysis" (p. 71).

I would commend, too—out of so many other points of agreement or controversy that one could raise without the least difficulty in so rich a field—his discussion of the corpuscle–fibre paradox and related questions. Man-made fibres, invented on the basis of tricks picked up primarily from Nature's workshops, are spun from more or less drawn-out chain-molecules, yet it turns out now that Nature herself seems to proceed more often than not by first stringing together unit packets of coiled and folded chains.

There are a few misprints and anomalies in spelling and grammar, and I must confess to having been peculiarly saddened to read 'flagellae' four times over.

W. T. Astbury

A KEY TO LEAF-MINING INSECTS

Bestimmungstabellen der Blattminen von Europa

Einschliesslich des Mettelmeerbeckens und der Kanarischen Inseln. Von Prof. Erich M. Hering. Band 1: Pflanzengattungen A-L. Erzeuger Nr. 1—3133. Pp. 648. Band 2: Pflanzengattungen M-Z. Erzeuger Nr. 3134—5551. Pp. 535. Band 3: Neubeschreibungen von Minen-Erzeugern Systematische Ubersicht der Wirtspflanzen und der Minen-Erzeuger. Abbildungen. Pp. 221 (86 tafeln). (The Hague: Dr. W. Junk, 1957.) Complete set, three volumes, 180 guilders. [About £18.]

LEAF-MINING insects feed on plant leaves, not by biting pieces out of them (like most caterpillars) but by destroying either the pallisade tissue or the spongy parenchyma, or both. The 'mines' are of very diverse forms, and are often characteristic of the species of insect which causes them. As a rule the damage, though unsightly, and such as to impair the efficiency of the leaf as a functional organ, is of little economic significance. However, some crops may, from time to time, be seriously damaged, so the group is potentially dangerous. Thus the mangold fly, whose larvæ can usually be found in any field mining the leaves of sugar beet, often does little damage to the crop, but it may cause losses exceeding three tons per acre. Agricultural and horticultural entomologists often find leaf-mining insects or observe the damage they cause, but identification of the insects often presents serious problems. Coleoptera, Hymenoptera, Lepidoptera and Diptera all have species with the leaf-mining habit, but this habit may be confined to one member of a family, and similar damage may be caused by widely separated species of insects.

In the first two of the volumes here considered the various host plants are listed alphabetically, and there is then given for each plant a key listing all the mining insects, with a brief description of the damage they cause. The author has interpreted his subject rather liberally, so some insects which might be considered as gall producers are listed here as miners, but this adds rather than detracts from the value of the book to most users. 5551 instances of mining damage are listed. The keys are well and simply laid out, so those who do not read German easily should be able to use them without difficulty.

Vol. 3 lists and describes a dozen new species of leaf-mining Diptera, and one new lepidopteran. It includes a list of the food plants, and of the families of insects involved. 170 pages contain 725 line drawings, mainly featuring the damage caused to plants by these insects. The figures are quite well drawn and reproduced.

These volumes will be a useful tool to agricultural entomologists and others, but it is a pity they could not have been produced more cheaply. The printing and paper are good but the books are poorly bound in flimsy paper covers. Notwithstanding the usefulness of the contents they seem expensive at eighteen pounds for the set of three modest volumes.

KENNETH MELLANBY

TRAINING MANAGERS

New Ways in Management Training

A Technical College Develops its Services to Industry. By Cyril Sofer and Geoffrey Hutton. Pp. xii + 127. (London: Tavistock Publications, Ltd., 1958.) 15*s*. net.

CONCERN to make his department of more value to industry in the training of managers led Robert Harcourt, head of the Department of Management and Production Engineering at the Brunel College of Technology, to initiate the study which is described in this book. The objects of the study were to examine the function and possibilities of a department of management and production engineering in servicing industry, how industry could make known its wants and needs as well as the way industry could help the department. The task was entrusted to the Tavistock Institute of Human Relations and, in collaboration with members of the Brunel College staff, was carried out during 1954–56.

While their report on this valuable investigation will be of interest to their fellow social scientists, Sofer and Hutton's account is likely to be of more direct value to training officers, educational administrators and many industrial managers. It will be of even greater relevance to those responsible for the control and development of technical colleges.

To set the study in its right background, an account is given of the place of the technical college in the national educational system and its place *vis-à-vis* the universities and other organizations in the training of management for industry. This is followed by details of the kinds of students who attend management courses at technical colleges, together with reasons as to why they attend. These are sometimes illuminating. Most of those who were studying for management certificates, for example, saw their courses as in some way a contribution to their personal advancement; most of the management students expected to get better jobs with employers other than their own. Few students had really high ambitions and a not infrequent comment was: "I don't think I'll ever get to director level because you need social connections for that. Somebody who is likely to finish up at that level would not have come from a technical college, but would have taken a Cambridge degree".

One of the great weaknesses of technical college classes is borne out by the finding that most students did not expect to find discussions with fellow students very helpful to learning. Each student's contact with others was said to be minimal: "Hardly any friendships were developed within the class and very little discussion of course material took place spontaneously. . . . At the end of the evening everybody went home—they were tired and hungry".

The attitudes of firms in Acton to technical colleges and their staffs can be regarded as typical for the whole of Great Britain. Although educational and scientific pursuits rank fairly high as social activities in Britain, the status of technical colleges among them is low; they are thought to serve a less-important purpose than more 'academic' institutions, and to be concerned more with training in specific craft skills than with the preparation of young people for life or for positions of social leadership and responsibility. Teachers in technical colleges are regarded more as school teachers than university lecturers, and as persons of mediocre calibre. The technical college teacher was thought to be insufficiently appreciative of production management, 'up in the air' and over-theoretical; it was often said that a man who really knew management and could practise what he preached would be a manager, not a teacher. Larger firms felt no need for the services of management and production engineering departments except for a limited amount of junior supervisory classes and for management courses of the conventional type; smaller firms made demands for courses in the organization and supervision of production and in general education.

The rest of the book describes how Sofer and Hutton and their collaborators attempted to find a way through this wall of prejudice. After considerable resentment had been dissipated, the teachers began to understand that the views of the industrialists were not wholly distorted; the industrialists began to realize that under their noses was a most valuable service if they cared to use and contribute to it. Detailed surveys were carried out in firms to show how the department could be of greater value to them and, eventually, separate advisory panels were formed to make a permanent link between the College and industry. Finally, members of the Tavistock Institute of Human Relations were asked to organize a course to help the teachers to become more expert in dealing with students from industry and industrial affairs. It needs little reading between the lines to appreciate that this was far from successful and that the approach of the academic social scientist in teaching teachers has considerable limitations.

Of the study as a whole, not much need be written. Harcourt and all those concerned at the Brunel College of Technology deserve applause for their courage and perspicacity in initiating the project. The Tavistock Institute of Human Relations should be congratulated for the way it saw and grasped an opportunity to improve the quality of management education at Acton and elsewhere. Sofer and Hutton are to be warmly commended for carrying out a difficult survey in an objective and discerning manner and for recording it so intelligibly. This is so out of keeping with other publications of the Tavistock Institute that it scarcely seems possible that this book could have been produced under its auspices. By this important work Sofer and Hutton have not only made a contribution to the development of better management education at technical colleges, but may also have reconverted leading industrialists to the belief that the Tavistock Institute really has a contribution to make to the solution of many industrial problems.

T. H. HAWKINS

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by A. H. W. BECK, *B.Sc.(Eng.), A.M.I.E.E., Standard Telecommunications Laboratories Ltd.*

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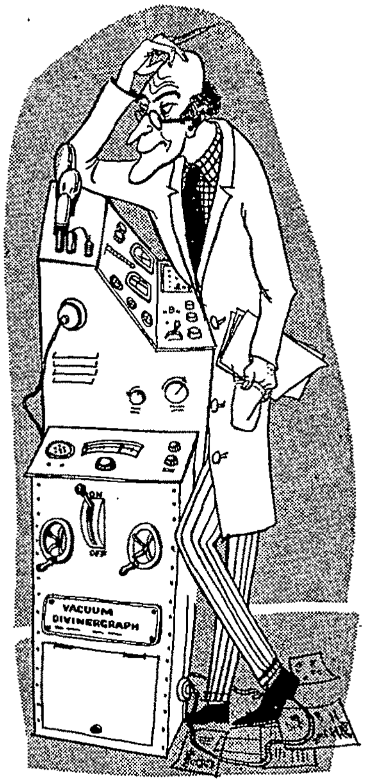

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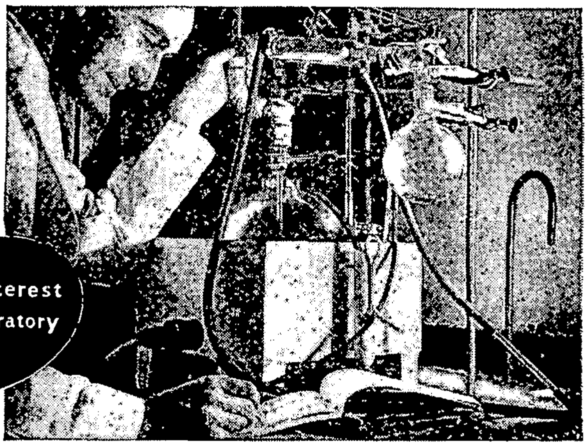

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items of interest from our laboratory notebooks

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We have added so many metal indicators (for EDTA titrations) to our range since the last edition of our catalogue that we hesitate to pick on any one for special mention. The most recent was **Naphthyl Azoxine** (H. & W. Code 5959) for Cd, Co, Cu, Pb, Ni and rare earths (see **Anal. Chem.**, 1957, **29**, 821), but we have most others already in stock.

Nitrosoresorcinol monomethyl ether is a comparatively new colorimetric reagent for iron and cobalt. There are others, of course, but S.M. Peach (**Analyst**, 1956, **81**, 371) considers that this one has some particular advantages. For instance, the Co complex can be extracted into an organic solvent. The reagent will appear as an addition (H. & W. Code 6303) in our next catalogue amendment.

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La Lutte contre *Stephanoderes hampei* Ferr.

Par G. Schmitz et P. Crisinel. (Série Scientifique, No. 70.) Pp. 156. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1957.) 130 Belgian francs.

THE coffee berry borer beetle, *Stephanoderes hampei*, is one of the important pests of a tropical crop, and its control by insecticides has been reconsidered since the development of chlorinated hydrocarbons and organic phosphorus compounds. Primarily a pest of *robusta* coffee, this small Scolytid was introduced into South America and the East Indies in early consignments of seed from tropical Africa. It causes shedding of the developing coffee cherry and damage to the bean.

Schmitz and Crisinel give the results obtained between 1950 and 1955 in controlling *Stephanoderes* on a field scale in the north-east of the Belgian Congo. Trials were carried out with a number of chemicals, including DDT, BHC, dieldrin and parathion. These were applied in a wide variety of ways from hand dusting and spraying to power-operated machines. The best results under prevailing local conditions were obtained with an endrin emulsion and a power-operated atomizer, 'Swissatom 2000', for which operating costs are given in detail.

The fact that successful pest control depends on a thorough knowledge of the pest is recognized by the authors, who devote nearly half their paper to establishing the background against which they had to work. A historical survey of *Stephanoderes* as a pest of coffee, supported by a detailed bibliography, is followed by an account of its life-history, and by a statement of the problem from the point of view of coffee production. The whole problem of 'shedding' as found in plantations in Uele is discussed in relation to the proper diagnosis of the part played by *Stephanoderes vis-à-vis* fungus attack and physiological disturbance of the coffee bush.

The Institut National pour l'Étude Agronomique du Congo Belge and the Compagnie Cotonnière Congolaise are to be congratulated in collaborating in establishing this work on so wide a basis. Schmitz and Crisinel have, in consequence, produced a report which will be of great value to those interested in the wide field of crop protection in the tropics.

W. V. HARRIS

Chromatographic Techniques

Clinical and Biochemical Applications. By Dr. Ivor Smith. Pp. xiii+309. (London: William Heinemann Medical Books, Ltd., 1958.) 45*s*. net.

THIS is rather different from the general run of books on this subject. It is confined mainly to the application of paper chromatography to substances of clinical interest. No attempt is made to cover the innumerable methods; instead, one single apparatus for one- and two-dimensional separations is described and a minimal number of solvent systems and location reagents of proved usefulness have been selected. Opening chapters deal with apparatus and give a full account of the methods of desalting and preparing fluids for chromatography. Chapters then follow, each devoted to recommended procedures for preparing chromatograms of amino-acids, sugars, barbiturates, indoles, steroids, phenolic acids and so on, in human blood, urine and tissue fluids. Some of these chapters include very useful sections on clinical interpretations of chromatograms in disease. Final chapters give guidance for further investigations of unknown constituents observed on chromatograms and describe model experiments for students. The uniform style of the chapters reflects careful editorship and close collaboration with the various authors. The result is an attractive book, which within its limits contains a tremendous amount of information most attractively presented; it should prove of the greatest value for research workers in clinical chemistry, and because it has sought to standardize methods it should stimulate the wider adoption of paper chromatography for routine clinical chemical purposes and even encourage the general practitioner to use the method.

R. CONSDEN

Stedman's Medical Dictionary

Edited by Norman Burke Taylor in collaboration with Lieut.-Col. Allen Ellsworth Taylor. Nineteenth revised edition. Pp. xlvi+1656. (London: Baillière, Tindall and Cox, Ltd., 1957.) 88*s*.

THIS weighty volume provides brief definitions of many thousands of medical, dental, veterinary, chemical and botanical terms, together with notes on their derivation and pronunciation. Short biographical sketches of outstanding figures in medical history are included. A separate, 36-page section on medical etymology precedes the main work, and this most informative contribution should be of the highest value to medical students unversed in Greek and Latin. An appendix contains, among other useful data, comparative tables of weights and measures, temperature and barometric scales, and anatomical nomenclatures.

The dictionary itself satisfies the essential requirement of any medical dictionary, that it be reasonably comprehensive, accurate and lucid. It is not free from mistakes and misleading statements; on p. 787 "splenomedullary" leukæmia is described as the commonest form of leukæmia, with marked leucocytosis, "large uninuclear eosinophile myelocytes predominating"; acute leukæmia is not listed as such; under "hemoglobin" only three abnormal forms are mentioned; and in many minor respects definitions are sometimes not in keeping with current beliefs. Blemishes of this sort are inevitable in so massive a work, and are, of course, confined chiefly to subjects in which medical advance has been rapid. A more serious drawback for the British reader is the American spelling, regrettably often different from that used in this country, which renders the dictionary unsuitable for use by medical secretaries and typists.

F. G. J. HAYHOE

Observations on Birds of Southeastern Brazil

By Margaret H. Mitchell. Pp. x+258+11 plates. (Toronto: University of Toronto Press; London: Oxford University Press, 1957. Published for the Division of Zoology and Palæontology, Royal Ontario Museum.) 45*s*. net.

THE birds of South America and their taxonomy are very well known; very little has been recorded on what the birds look like and how they behave in their natural surroundings, and what these surroundings are. This book is a valuable collection of field observations on 289 species occurring in south-eastern Brazil. The author resided in Rio de Janeiro for four years and had opportunities of visiting the adjacent States. Field identifications were checked against specimens in the São Paulo State Museum and with the aid of Dr. Olivério Pinto. Although mainly concerned with field study, Mrs. Mitchell did not neglect to become conversant with relevant literature and the text is annotated with more than 100 references. The style is pleasantly informal and very easy to read.

MEASUREMENT OF THE ENERGY SPECTRUM OF PROTONS EMITTED FROM THE FUSION REACTION IN SCEPTRE III

By W. M. JONES, A. C. L. BARNARD, S. E. HUNT and D. R. CHICK
Research Laboratory, Associated Electrical Industries, Ltd., Aldermaston, Berks

DEUTERIUM fusion may proceed by two reactions, D(dp)^{3}H and D(dn)^{3}He, which occur with almost equal probability at low deuteron energies. Measurements on the energy spectrum of the neutrons emitted from ZETA have already been reported[1], but no measurements of proton energy have yet been reported from fusion reactions occurring in gaseous discharge systems.

If fusion is induced by deuterons having only thermal motion, the energy spectrum of the protons will be independent of the angle of observation, whereas if some process producing a preferred direction in the deuteron motion is involved, the proton energy will depend on the angle of observation with respect to the preferred direction of motion.

The present communication describes a preliminary investigation of the proton spectra from Sceptre[2] using cameras with nuclear emulsion plates inserted into the torus. The cameras protruded only slightly inside the walls of the torus and did not produce any measurable fall in the externally measured yield of neutrons, so that their presence did not appear to modify the discharge mechanism. They were arranged to accept protons emitted at nominal angles of 30°, 90° and 150° to the direction of flow of positive gas current. In order to prevent surface fogging of the plate due to low-energy radiation and light from the discharge, it was necessary to protect the plates by thin copper-foil windows.

The proton energies were estimated using the range–energy relationship for protons in Ilford *C*2 emulsion[3], a correction being applied for the loss of energy in the copper foil[4]. The measured dip angles and the theoretical shrinkage factor were used in deducing the range. Additional exposures were made at 90° using a camera of better geometrical definition, with which the angle of entry into the emulsion was known directly from the geometry. This permitted more precise absolute measurements to be made of the proton energies at 90°. The mean energy of this proton group was 3·03 ± 0·02 MeV., which shows that the protons originated in the (d–d) fusion reaction.

The proton yield estimated from the track density and camera geometry was consistent with the neutron yield estimated by external liquid scintillation counters. From the direction of the proton tracks in the 90° plates, it could

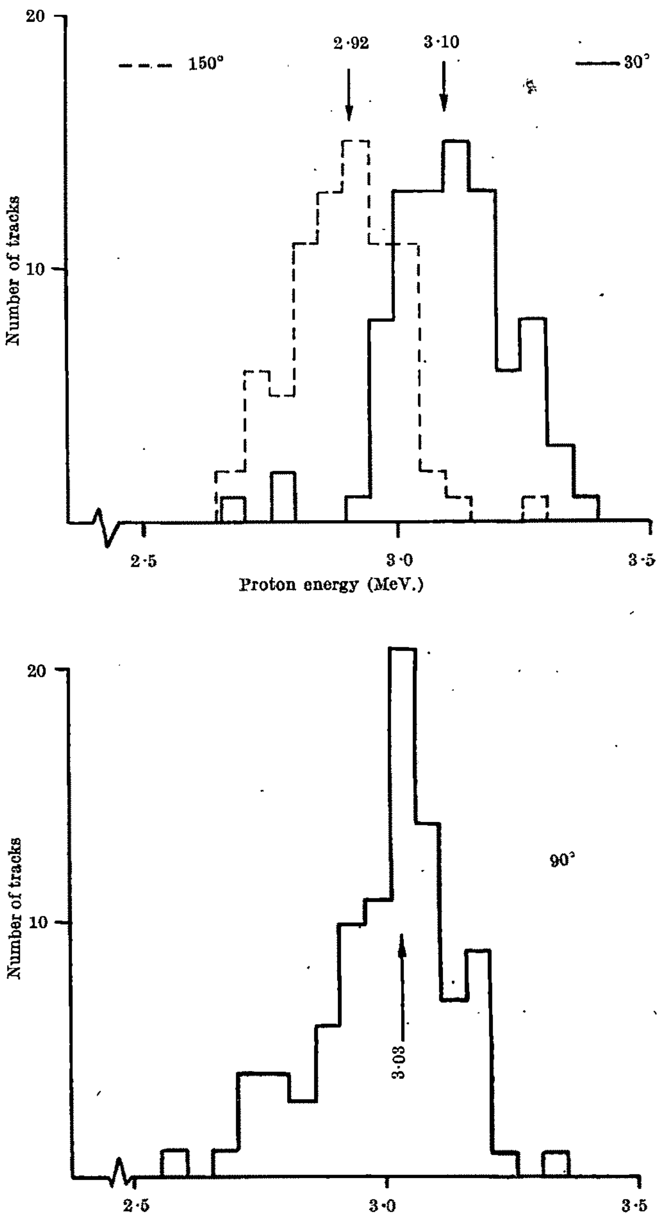

Fig. 1. Histogram of proton energy measurements at 150°, 30° and 90° to direction of positive gas current flow

Table 1. TORUS : SCEPTRE III

Date of exposure	No. of discharges	Deuterium pressure in torus	Condenser voltage (kV.)	B_z field (gauss)	No. of primary turns	Peak torus gas current (k.amp.)	Angle of observation	No. of proton tracks measured	Mean energy of proton group	Standard deviation	Estimated total error
31/5/58	4,477	1·4μ	25	500	16	100	30°	44	3·11	0·02	±0·03
16/6/58	5,000	1·4μ	25	500	16	100	30°	40	3·10	0·02	±0·03
20/5/58	7,980	1·4μ	25	500	16	100	90°	93	3·03	0·02	±0·02
11/6/58	5,900	1·4μ	25	500	16	100	150°	36	2·94	0·02	±0·04
15/6/58	5,000	1·4μ	25	500	16	100	150°	20	2·91	0·03	±0·04
17/6/58	5,400	1·4μ	25	500	16	100	150°	22	2·90	0·03	±0·05

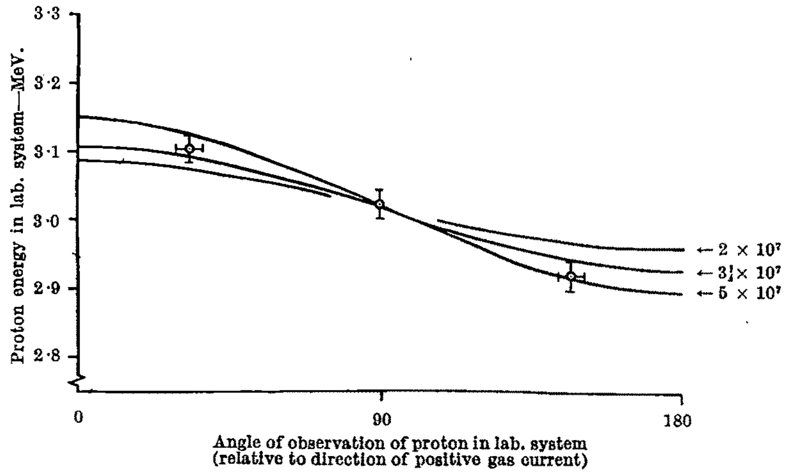

Fig. 2. Variation of mean proton energy with angle of observation

be deduced that most of these originated from the centre (one-third or one-half) of the discharge tube.

Energy spectra obtained at 30°, 90° and 150° are shown in Fig. 1. The energy values obtained for the three angles of observation are given in Table 1, together with the conditions under which the exposures were made. The errors were obtained by combining the statistical standard deviations with the errors associated with measurements of foil thickness and possible slight differences in density between the emulsions used in the measurements.

The results indicate that the majority of protons observed originate from fusion between deuterons the centre of mass of which has a velocity component in the direction of positive gas current flow. In Fig. 2 the observed variation of proton energy is plotted and compared with that calculated for deuteron centre-of-mass velocities of 2×10^7, 3×10^7 and 5×10^7 cm. sec.$^{-1}$ relative to the laboratory. The results give the best fit for a centre-of-mass velocity of about 4×10^7 cm. sec.$^{-1}$. This is less than the velocity of centre of mass indicated by the published results for ZETA[1].

We wish to thank the members of the Thermonuclear Section of this Laboratory and Mr. E. D. Taylor for their assistance in the experimental work, and Misses S. J. May and O. V. Lake, who scanned the plates. Thanks are also due to Dr. T. E. Allibone for his great interest and encouragement in this work and for permission to publish these results. The work has been supported in part by an Atomic Energy Research Establishment contract for thermonuclear research.

[1] Rose, B., Taylor, A. E., and Wood, E., *Nature*, **181**, 1630 (1958).

[2] Allen, N. L., *et al.*, *Nature*, **181**, 222 (1958).

[3] Rotblat, J., *Nature*, **167**, 550 (1951).

[4] Whaling, W., Kellogg Radiation Laboratory Data Sheet.

PEACEFUL USES OF ATOMIC ENERGY

SYMPOSIUM IN AUSTRALIA, 1958

A SYMPOSIUM on "The Peaceful Uses of Atomic Energy" was held in Sydney during June 2–6, organized by the Australian Atomic Energy Commission, the Australian universities, and a number of Australian industrial organizations.

The symposium was a major success and, in its stimulation of thought on matters related to atomic energy among all sections of the community in Australia, exceeded the hopes of even the most optimistic of its initiators. Several reasons have emerged for these results. The Australian Atomic Energy Commission's high-flux research reactor at Lucas Heights became divergent earlier in the year (see *Nature*, May 24, p. 1433); radiochemical and other laboratories have been commissioned and are being made ready to examine the products of the reactor when it is taken in some months time to its full power of 10 MW. Australian universities have introduced, or are considering, postgraduate courses in nuclear engineering and science. There has been a general increase in the tempo of nuclear research in universities, spreading from nuclear physics to other disciplines. Formal arrangements with the universities of Australia for their use of the facilities of the Lucas Heights Research Establishment have been made by the formation of the Australian Institute of Science and Nuclear Engineering. Under the stimulant of the Commission's isotopes advisory service, Australian industry has taken a rapidly increasing interest in the immediate applications of atomic energy. In the mining area, the uranium oxide production plants in Rum Jungle and Radium Hill are in full production, and the large plant at Mary Kathleen started production during the symposium.

With this background of atomic energy developments in Australia, a total of 435 delegates, including 38 from overseas, came to the symposium to discuss a total of 114 papers. The overseas delegates from the United Kingdom, the United States, Canada, France, New Zealand and Pakistan, particularly those countries well advanced in atomic energy developments, provided an energetic complement to the Australian contributions.

A considerable interest was displayed by the general public of Australia. A comprehensive atomic energy exhibition featuring displays from Australia and other participating overseas countries was well attended by members of the public. Prof. M. L. E. Oliphant's lecture to 2,500 school children was so popular that it had to be given in two sessions. A number of leading overseas scientists gave addresses on the radio and to scientific societies. Vigorous public questionnaire sessions from forums of local and overseas scientists were arranged as both 'live theatre' and television sessions.

The symposium was divided into five sessions: Section 1, Materials; Section 2, Power Engineering;

Section 3, Power Auxiliaries and Research Reactors; Section 4, Basic Sciences; and Section 5, Associated Techniques.

A period during the last day of the symposium was devoted to developments in the thermonuclear field. Dr. T. E. Allibone described the gas-discharge work at Harwell and at the A.E.I. Research Laboratories at Aldermaston. Dr. W. H. Pennington read a paper by Dr. A. E. Ruark describing the American programme. Prof. Oliphant discussed proposed experiments in Australia with the Canberra homopolar generator. These developments in thermonuclear experiments were of particular interest to Australia in that they gave a full account of the achievements and difficulties in this only recently declassified field.

Materials

The papers on materials can be divided naturally into two groups. The first dealt with minerals and ores containing uranium and thorium, with their occurrence in various parts of Australia, and with the several plants now operating for their extraction. The second group was concerned with actual or potential reactor materials, with their preparation and fabrication, and their properties.

In the first group there were papers dealing with the distribution of minerals important for atomic energy in South Australia (W. Johnson), in the Northern Territory (B. P. Walpole), in New South Wales (E. O. Rayner), and in Queensland (J. H. Brooks). These papers gave an up-to-date picture of the known deposits of ores of uranium and thorium in these States, with a good deal of information on the geology of the areas concerned.

One paper dealt with the instrumentation problems of the search for uranium and thorium (J. Daly and D. F. Urquhart). This covered the design of equipment for assaying and for prospecting, the latter use presenting the main problems. Equipment for use in moving vehicles and for bore logging, based on Australian experience, was described.

Australia's main uranium-producing plants were the subject of several papers. The production of uranium concentrate at Rum Jungle was described by Baker, and the somewhat different processes used at Radium Hill were described in two papers, the first (T. A. Rodgers) dealing with ore production and physical concentration, while the second (J. N. Arnold) dealt with the chemical extraction of uranium, and its recovery by ion exchange methods from the physical concentrates. A fourth paper (R. A. Couche and F. R. Hartley) gave a detailed account of the processes worked out for the recovery of uranium from the Mary Kathleen ores in Queensland. These papers brought out the differences in behaviour of the ores at these plants, all of which produce oxide concentrate of roughly the same type.

An important paper in this group was that entitled "The Jigged-Bed Ion Exchange Pilot Plant for Uranium Extraction", by G. L. Herwig, R. M. Stewart, E. A. Swinton and D. E. Weiss. It describes the plant and operating results, when extracting uranium from an acid pulp of low filtering properties, using a continuous ion-exchange process which does not require the pulp to be filtered. The process was used to treat experimentally one of the more difficult Rum Jungle ores.

The other half of this materials section consisted of nineteen papers. Australian interest in the development of the high-temperature gas-cooled reactor and the reactor fuelled with liquid metal was shown by a group of papers dealing with ceramic nuclear fuels, and problems relating to liquid metals. "Ceramics as Reactor Materials" (K. D. Reeve), "The Preparation of Thorium Carbide" (D. E. Scaife and A. W. Wylie), "Ceramics and Cermets Investigations" (L. S. Williams and J. Graham) were examples of such papers.

A considerable study of reactor materials, including graphite, zirconium and aluminium alloys and uranium dioxide fuel elements, was given in a paper entitled "Recent Progress in Reactor Materials Development" by F. N. Albaugh, R. E. Nightingale, E. A. Evans, J. W. Riches and R. L. Dillon.

The commercial process now adopted for the production of uranium metal in the United States was described by F. L. Cuthbert. The stages of leaching, solvent extraction, the production of 'green salt' and its reduction to uranium metal were all described. This paper also described the casting and machining or uranium and its alloys, and the recovery of the metal from process scrap.

On the technology of liquid metals, a paper by F. L. Bett was concerned with compatibility studies between liquid sodium and niobium, and a paper by H. M. Finniston dealt with corrosion in liquid-metal systems. This paper discussed the mechanism and kinetics of mass transfer in solid metal – liquid metal systems, such as may be encountered in reactors fuelled with liquid metal.

Other papers in this group dealt with the production of uranium metal powder by a hydriding process (J. W. Kelly), with the production of uranium metal powder by reduction with calcium of uranium oxide (R. H. Myers and R. G. Robins) and with the production of uranium metal powder by electrolysis (R. G. Canning). B. C. Woodfine presented a study of the materials problems in producing fuel cans for gas-cooled reactors, operating at higher temperatures than are used at present. He dealt with the magnesium alloys which are now favoured, and went on to discuss beryllium, carbon and stainless steel for this purpose.

The miscellaneous part of this section included papers on fusion welding of reactive metals (J. M. Newburn), irradiation effects on uranium and its alloys (H. M. Finniston), levitation heating (B. Harris, E. G. Price and A. E. Jenkins), neutron diffraction studies of compacts (T. M. Sabine and K. D. Reeve), materials for control of reactors (W. J. Wright and K. P. Nicholson) and studies of the lower halides of niobium and zirconium (I. E. Newnham).

The meetings of the materials section were marked by lively discussion throughout.

Nuclear Power Programmes

Section 2 covered papers on national atomic power programmes, specific power-reactor developments, and some papers on the economic questions that might be raised in the development of atomic power in Australia.

Five papers were presented on the national development of atomic power. They were: "The Nuclear Power Programme in the U.K." (H. H. Gott); "Development of Nuclear Power in the U.S.A." (L. H. Roddis); "The Canadian Nuclear Power Programme" (D. G. Hurst); "French Private Industry in the Atomic Field" (P. M. C. Retourna); "Possible Developments in Nuclear Fuel Cycles in Australia" (J. P. Baxter and C. N. Watson-Munro).

H. H. Gott's paper dealt briefly with the United Kingdom programme of installation of graphite-moderated natural uranium power reactors using carbon dioxide cooling. He discussed the advances that are taking place in the design and the development of these reactors and pointed out that the United Kingdom would only change to a significantly different type of reactor design if a new reactor could with considerable certainty generate power at a lower cost than those under construction.

P. M. C. Retourna outlined the contributions of French private industry to the French graphite-moderated natural uranium power reactors using gas cooling, and to the subsidiary industries such as graphite, calcium and zirconium production, chemical extraction and processing plant.

The extensive United States programme of reactor experiments, demonstration power reactors and full-scale power reactors was described by L. H. Roddis. He outlined the breadth of the American research and development programme in pressurized-water reactors, boiling-water reactors, sodium – graphite reactors, fast-breeder reactors, aqueous homogeneous reactors, organic moderated reactors, liquid-metal fuel and molten-plutonium systems and gas-cooled reactors.

D. G. Hurst outlined the programme of development of heavy-water natural uranium reactors in Canada and described the nuclear-power demonstration reactor under construction at Des Joachims. He described the conceptual design features of a 200-MW. (electrical) reactor under consideration by Atomic Energy of Canada, Ltd., in conjunction with the Hydro-Electric Power Commission of Ontario.

J. P. Baxter and C. N. Watson-Munro stressed the need for nationally integrated fuel cycles in Australia. Based on a number of speculative assumptions of nuclear power requirements, proportions of natural uranium and enriched reactor systems, they made some estimates of the order of requirements of Australia's needs of fertile and fissile materials during the next four decades.

The four papers on specific power reactor developments from the large British nuclear consortia, namely, "Medium Output Gas-cooled, Graphite-moderated Reactors for Australia", by A. L. Shaw (A.E.I.), "Engineering Aspects of Nuclear Power Stations employing Gas-cooled, Graphite-moderated Reactors", by K. J. Wootton (General Electric Co.), "Design of the Gas-cooled, graphite-moderated Reactor for Power Production", by R. D. Vaughan (Nuclear Power Plant Co.), and "The Hinkley Point Reactors", by Dr. H. S. Arms, C. Bottrell and P. H. N. Wolff (English Electric Co.), provided a great deal of interest.

These firms have recently given tenders in the United Kingdom for a total of about 1,400 MW. of electrical capacity, and construction work has begun on all four nuclear power stations. As one speaker put it, "The British Electrical Industry had not established a reputation as a charitable institution", and it was obvious from the papers and from the subsequent discussions that these reactor designs represented a 'down to earth' approach to the problems of providing a significant and reliable contribution to the British electricity grid. All four gave broad descriptions of current designs and discussed the areas in which improvements and reductions of cost could be achieved. Two of the papers discussed possible applications of this type of reactor to Australian conditions, and some estimates of costs—both current and futuristic—were given for reactors ranging from 60 MW. upwards.

J. M. Harrer delivered a paper entitled "Operational Data and Experience from the Experimental Boiling-water Reactor". In this paper he detailed the actual operating experience obtained over a period of twelve months with this reactor; during this period no major technical fault had developed and the claims of compactness, simplicity, safety, reliability and convenience had been substantiated.

Two papers discussing the possibilities of the reactor systems under investigation by the Australian Atomic Energy Commission Research Establishment were presented. They were: "Gas-cooled Reactors of a Mixed-fuel Moderator Type", by G. C. J. Dalton, and "Liquid-metal Fuel Reactors", by K. F. Alder. Both these reactor systems have a number of possibilities of choice of moderator, fuel diluent and coolant, but neither has yet reached the stage of a reactor experiment.

Three papers on economic questions in the development of nuclear power in Australia were presented: "The Growth in Demand for Electricity in Australia", by the Australian Department of National Development; "Atomic Power in Australia—some Economic Consideration", by the Commonwealth Bank Discussion Group; and "The Economics of Electricity Generation in Queensland and the Potential Employment of Nuclear Reactors", by R. D. Waldie.

The paper by the Department of National Development, from an examination of the relationship of growth-rates of population, real national *per capita* income, energy consumption and electrical-energy consumption, made some estimates of the growth-rates of Australian electricity demand for the next four decades.

The paper by the Commonwealth Bank examined the impact that the installation of nuclear plant of high capital cost would have on the capital demands of a rapidly developing country such as Australia. That by R. D. Waldie discussed the possible application of nuclear power to the widely separated electrical networks in the large State of Queensland and came to the conclusion that the Mt. Isa mining area offers the best possibilities.

Power Auxiliaries

This section covered research reactors, chemical processing, waste disposal and problems of power generation.

Five papers on research reactors were presented: "Canadian Research Reactors", by D. G. Hurst; "The Design and Construction of HIFAR", by W. H. Roberts; "The Control and Instrumentation of the Reactor HIFAR", by G. Page; "The First Year of Operation of DIDO", by F. W. Fenning; and "An Industrial Research Reactor", by T. E. Allibone, D. R. Chick and A. J. Salmon.

The paper by D. G. Hurst was a valuable one, particularly as Canada has had as much experience as any other country in the world in the operation of high-flux research reactors. F. W. Fenning's paper was particularly useful to Australia; except for some minor modifications described by W. H. Roberts, the Australian reactor HIFAR is a copy of DIDO, and the British experience will be invaluable in considering its operation.

The paper on the A.E.I. pool-type research reactor, presented by T. E. Allibone, evoked considerable interest as an example of an industrial firm constructing a research reactor of relatively low cost with neutron fluxes remaining close to 10^{14} neutrons per cm.^{2} per sec.

The four papers presented in the sub-section on power generation were: "Nuclear Steam-power Plant for Waterless Zones", by W. R. Wootton; "Similitude in Gas Turbines for Nuclear Power Plants", by G. G. McDonald; "Nuclear Power Reactor and Turbo-alternator Interaction under Dynamic Conditions", by H. K. Messerle and J. F. Armstrong; and "Heat Transfer in Homogeneous Gas-cooled Reactors", by G. de Vahl Davis.

The first of these was of particular interest to Australia in that it detailed a conceptual design and cost estimate of a 30-MW. (electrical) PIPPA type reactor, employing a sealed air-condenser.

Three papers on chemical processing were presented: "Chemical Reprocessing of Irradiated Fuels", by J. E. Cole; "The Future of Nuclear Fuel Processing in Australia", by G. L. Miles; and "Acid Leaching and Anodic Dissolution of Graphite-moderated Fuels", by K. R. Hyde, D. J. O'Connor and J. L. Woodhead.

J. E. Cole gave a brief survey of American practice in processing plants and gave a cost estimate of a plant capable of processing 10 tons a day of irradiated natural uranium. A number of questions were posed by Australian members of the audience on the design and economics of smaller plants. Some estimates of the likely requirements of chemical processing in Australia and of the possible kinds of plant that might be used were given by G. L. Miles.

The two papers on the treatment of waste, "Philosophy and Practice of Radioactive Waste Disposal", by R. B. Temple, and "Handling, Treatment and Disposal of Radioactive Wastes", by J. A. Lieberman, provided some lively discussion both on and off the symposium floor. It became obvious that a world appreciably powered by fission energy would need to retain control over the storage of fission products and could not allow uncontrolled disposal in the sea or elsewhere.

Basic Sciences

This section contained a wide variety of papers divisible broadly into theoretical physics, cosmic rays, reactor physics, radiation and nuclear chemistry.

The papers in theoretical physics, while of limited direct interest to the practical application of atomic energy, gave some basic scientific stimulation to the symposium. They were as follows: "Optical Treatment of Inelastic Scattering", by S. T. Butler, N. Austern and C. Pearson; "The Ground-state of the Triton; Effect of Repulsive Core Forces", by J. Blatt and G. Derrick; "The Ground-state of the Triton: Group Theoretical Classification of Wave Function", by G. Derrick and J. Blatt; and "Nuclear Forces at Very Small Distances", by S. T. Ma.

The same general remarks apply to the papers on cosmic rays, though in this case a number of papers had computing and instrumental techniques of special interest in the field of nuclear reactor research. The papers were as follows: "The Sydney Air Shower Experiment": (1) "The Experimental Apparatus", by D. D. Miller; (2) "The Determination of the Radial Distribution of Electrons and the Size Spectrum of Extensive Air Showers", by C. S. Wallace; (3) "The Zenith Angle Distribution of Air Showers", by J. Malos; (4) "The Radial Distributions of High-energy Nuclear-active Particles and of μ-Mesons in Cosmic-ray Air Showers", by J. A. Lehane.

Papers in the field of reactor physics and reactor theory were: "Some Recent Developments in the Theory of Doppler Broadening of Nuclear Resonance Regions", by J. L. Cook; "On the Second Order Terms in the Age Theory of Neutron Distribution", by L. C. Woods; "The HIFAR Oscillator", by K. P. Nicholson and A. W. Pryor; and "Neutron Diffraction on HIFAR", by T. M. Sabine. Whereas the first two of these contributed to existing reactor theory, the last two papers described specific instruments under construction for use with the Australian HIFAR reactor.

A wide range of papers was presented in the field of radiation, nuclear chemistry and chemistry, as can be seen by the following titles: "The Chemistry of Positronium", by J. W. Lee and J. H. Green; "Radiochemical Method for the Detection of Fast Neutrons", by R. Mills; "Free Radical Measurements in the Radiolysis of Liquid Hydrocarbons", by K. H. Napier and J. H. Green; "The Chemical Fate of a Radioactive Atom", by D. L. Baulch and J. F. Duncan; "Distribution Studies and Stereospecificity in Recoil Tritium-labelling of Organic Compounds", by W. G. Brown and J. L. Garnett; "The Chemical Fate of Recoiling Fission Fragments", by D. Hall; "The Solution of Lime in Liquid Calcium and its effect on the Reducing Properties of the Metal", by D. J. M. Bevan and F. D. Richardson; "The Oxidation of Particles of Uranium Dioxide", by J. S. Anderson; and "Imperfections induced in Solids by Fast-particle Irradiation", by P. G. Klemens.

These papers ranged from fundamental studies to applications outside the field of chemistry such as the paper by R. Mills on the use of the ^{56}Fe$(n,p)^{56}$Mn reaction as a threshold detector of fast neutrons.

Associated Techniques

Twenty-eight papers were presented in this section, covering a large number of topics between which there was little close relationship.

One group dealt with radioactive isotopes, the techniques of their use and their applications in various fields. A survey of the use of radioisotopes in Australia was presented by J. N. Gregory. He showed that the number of shipments of isotopes per million of the population is substantially less in Australia than in the United Kingdom, America or New Zealand. The use of isotopes is now expanding more rapidly, and with the prospect of supplies from Australia's new reactor rapid development of uses in future may be expected.

The medical uses of isotopes provided eight papers: "Evidence for a Direct Mechanism in Leukæmogenesis", by P. L. T. Ilbury; "Beta-ray Therapy with Strontium-90 Sources", by D. F. Robertson; "The Effect of Ionizing Radiation on the Synthesis of Porphyrins by the Red Blood Cells of the Domestic Fowl", by R. Tirrell; "Experimental Hæmatology using Iron-59 and Chromium-51", by I. Brading, E. P. George and R. J. Walsh; "Inaccuracy of the Colloidal Gold Method for determining Liver Blood Flow", by J. McRae, M. Playoust, R. Boden and C. R. B. Blackburn; "Localization of the Placenta using Radioisotopes", by E. P. George and D. McGrath; "Use of Radioactive Tracers in Cardiac Investigations", by E. P. George, J. Hickie, F. A. Rocke and W. A. Seldon; and "Radioiodine Studies of the Equilibrium Turnover of Thyroxine in the

Thyroid Gland", by T. H. Oddie and I. D. Thomas. All were from Australian sources and show the increasing interest in medical circles in the use of these substances.

J. Carpenter and J. S. Gladstones discussed the production of mutants induced by radiation in subterranean clover and lupins in Western Australia. Some mutants of possible commercial value have been produced and are being examined.

In a paper entitled "Analytical Chemistry in Atomic Energy", L. E. Smythe described some of the requirements for analytical work in this field. He discussed the uses of automatic coulometry, square-wave polarography, gamma-spectrometry, low-background beta-counting, infra-red spectrometry, mass-spectrometry, emission spectrography, X-ray spectrography and vacuum fusion analysis, in an analytical laboratory serving an atomic energy research establishment.

G. L. Miles and D. F. Sangster presented a detailed account of the facilities for radiochemical work at the Lucas Heights establishment of the Australian Atomic Energy Commission. They described the special facilities for working with high levels of radioactivity, the ventilation requirements and methods adopted to prevent the spread of radioactive contamination.

A comprehensive account was given by H. M. Finniston of the radioactive handling facilities at Harwell for metallurgical work with both alpha- and gamma-active materials. The paper described at some length the special problems of working with plutonium, and the ways in which complicated metallurgical procedures can be carried out while adequate protection is ensured. The problems of working with high levels of gamma-activity were also described, together with the techniques developed at Harwell for this type of work. D. Campbell Allen contributed a paper on "High Density Concrete for Radiation Shielding".

In the instrumentation group, papers were presented on "Some Temperature Effects of Geiger–Müller Tubes", by R. E. Belin; "A General Purpose Wide-range Electrometer", by C. T. Murray; and "Transistor Decade Scaling Circuits", by R. E. Aitchison.

The use of radioactive isotopes in connexion with measurement of the water content of soils was discussed by J. W. Holmes; and J. S. Watt and K. R. Lawther described the attenuation of gamma-radiation as a means of measuring the density of a slurry of tungsten powder and water moving in a pipe. B. J. J. McHugh and H. E. Booth presented a paper on the gamma-ray measurement of defects in poles and trees; cæsium-137 was used as the source of gamma-radiation and results were given on the detection of cavities, damage by white ants, and other defects, in this way.

In the chemical research field, a paper was presented on "The Diffusion of Hydrogen Sulphide Gas through Surface Films on Water" (J. G. Hawke), in which sulphur-35 was used. D. R. Llewellyn and A. L. Odell gave a paper entitled "The Use of the Isotopes Oxygen-18, Carbon-13 and Carbon-14 in the Study of the Exchange Reactions of the *tris*-Oxalato Chromium III Anion".

The only paper in the symposium on educational methods was delivered in this section. It was "Programme of Education for Nuclear Engineering and Science at the N.S.W. University of Technology", by L. C. Wood and J. H. Green. This paper described the Institute of Nuclear Engineering, which was established in this University in 1954 and which has developed during the past four years not only a substantial research programme in the University but also postgraduate courses in various branches of nuclear engineering and science. These are the only courses of this kind at present available in Australia.

J. P. Baxter
C. N. Watson-Munro

MIGRATIONAL DRIFT OF BIRDS PLOTTED BY RADAR

By Dr. DAVID LACK, F.R.S.

Edward Grey Institute of Field Ornithology, Oxford

It has long been known that land birds which normally migrate north-east – south-west across the main European land mass appear on the east coast of Britain with easterly winds, but rarely under other conditions[1]. Ritchie[2] showed precisely that differences in the point at which waxwings (*Bombycilla garrulus*) arrived on the British coast on different days were explicable if their courses were the resultant between their heading in a constant direction and the wind at the time. Williamson[3] made a systematic study of the appearance of migrant land birds off their normal route, showed that such migrational drift was common, and defined the types of weather which determine it, but differed from other authors in regarding it as "essentially a down-wind movement". He also considered it as occurring primarily in night migrants. The behaviour of migrants in a cross-wind is of special interest in view of experiments showing that migrants can head in a fixed direction by day if they see the Sun[4], and by night if they can see the stars[5], and that displaced birds can 'home' apparently through a sense of geographical position which depends on the Sun[4,6].

The course of migrant birds over the sea can now be removed from the realms of inference, since the 1-MW. 10-cm. early-warning radar sets of the Royal Air Force detect small birds to ranges exceeding 60 miles (Tedd and Lack, in the press). The following information concerning directions of flight has been summarized ahead of a detailed study, in view of the continuing research by others on both drift migration and bird navigation. Personal observations of migration on a radar plan-position display in Norfolk from March 29 until April 18, 1958, were supplemented by photographs of the same display, made available by the Research Branch, Fighter Command, taken about once an hour from March 15 until April 21, 1956, and four times a minute from February 24 until April 20, 1957, a few days being missed in both years. Hence there are records from Norfolk for three successive years covering the main departure period of the land-birds wintering in England, of which the commonest are starling (*Sturnus vulgaris*), blackbird (*Turdus merula*), redwing (*T. musicus*) and chaffinch (*Fringilla coelebs*), with various other less common species, mostly passerines. These birds set off in March and April from the east coast of England over the North Sea on their way to more northerly breeding grounds.

In the period studied, the echoes from migrant birds were usually commonest soon after it was fully dark, with a subsidiary peak soon after sunrise. The volume of migration was assessed from the density of the echoes, and the directions of movement from the after-glow, which shows previous positions of each echo. At any one time, the directions were usually spread over about 45°, sometimes more, and their mean was estimated by eye to the nearest compass point, except that when two points were almost equally favoured both were cited, while when the movement was nearly due east, care was taken to see whether it was, on average, slightly north or slightly south of east. Such estimates were made twice daily, in the evening well after dark, and soon after sunrise, usually over some two hours in each period. The speed and direction of the wind were taken from the figures for Hemsby, Norfolk, in the Daily Aerological Record of the Meteorological Office, which was the nearest available point to the sea area studied.

Williamson (ref. 3, p. 185) wrote that "lack of wind is believed to be the external factor stimulating the act of migration". Table 1 shows clearly the deterrent effect of strong wind, since scarcely any large migratory movements occurred when the surface wind exceeded 15 knots at night and 10 knots by day. The direction of the wind had little influence, Table 2 showing that large migrations occurred, by night and day, with winds in every quarter. There seemed to be a slight tendency, especially by day, to favour following winds and to avoid head winds; but nearly all the large movements occurred during cross-winds, which, in the prevailing anticyclonic conditions, were usually from the north-east or south-east, that is, partly opposed to the direction of travel.

Table 1. Wind-speed and Volume of Migration

Speed at surface (knots)	After dark No. of days on which migration was: small or none	large	After dawn small or none	large
0–5	4	9	12	9
6–10	10	37	22	17
11–15	11	20	22	6
16–20	15	4	12	3
21–27	4	0	2	0
Total	44	70	70	35

Notes: (i) Radar records for most days and nights March 15–April 21, 1956, February 24–April 20, 1957, and March 29–April 18, 1958; (ii) the surface wind was recorded at Hemsby, Norfolk, at respectively 2000 and 0500 hr. in 1956 and March 1957, and at 1700 and 0800 hr. in April 1957 and 1958.

Table 2. Wind-direction and Volume of Migration

Direction of surface wind	After dark No. of occasions when migration was: small or none	large	After dawn small or none	large
Following (260°–280°)	0	2	1	5
Partly following (200°–250°, 290°–340°)	5	11	4	7
Cross (170°–190°, 350°–010°)	5	18	7	7
Partly opposed (020°–070°, 110°–160°)	8	27	7	7
Opposed (080°–100°)	3	3	4	2

Notes: (i) Winds recorded at Hemsby, as noted in Table 1; (ii) all occasions were omitted in which the wind was less than 6 knots, and also those with a small migration in which the wind was more than 15 knots by night and more than 10 knots by day.

Table 3. Direction of Wind at 900 m. and Direction of Migration

Mean direction of bird migration in North Sea	No. of occasions on which direction from which wind blew at 900 m. at Hemsby was: East 080–100	Southerly 110–160	170–190	200–250	West 260–280	Northerly 290–340	350–010	020–070
				After dark				
N.N.E.		1						
N.E.	1	6	6	3				
N.E.–E.N.E.		3	3	1	1			
E.N.E.	2	5	2	6	4	1		
E.N.E.–E.					6	1	1	1
E.		1			2	1	4	4
E.–E.S.E.						1	3	
E.S.E.				1		3	5	3
E.S.E.–S.E.								1
S.E.						1	1	7
				After dawn				
N.E.		6	2	2				
N.E.–E.N.E.		1	2	1				
E.N.E.		2	2	4	1			
E.N.E.–E.			1	2	2	2		
E.	1	1	1		3	6	1	1
E.–E.S.E.				1		3	1	1
E.S.E.		1				2	2	3
E.S.E.–S.E.							1	3
S.E.						1	1	2
S.S.E.								2

Note: Directions were usually spread over about 45°, sometimes more. The mean was estimated by eye, whenever possible to one of the main compass directions. Two directions are joined, for example, N.E.–E.N.E., when there were about an equal number of each on the occasion concerned.

The evidence from radar height-finders and other sources indicates that most of the migrants were travelling between 2,000 and 4,000 ft. above sea-level; hence for analysing the influence of the wind on the directions taken, the figures for the wind at 900 m. were used, and these, in fact, gave smoother results than those for the wind at the surface or at 1,500 m. Using only the direction of the wind (wind-strength will be analysed later) Table 3 suffices to show that the course taken, both by night and by day, is the resultant between a more or less constant heading (probably slightly north of east) and the wind at the time. On almost every occasion when the wind (at Hemsby) had a southerly component, the migrants over the sea travelled on a course north of east, and on almost every occasion when the wind at Hemsby had a northerly component, they travelled on a course south of east. Further, nearly all the few apparent exceptions to this statement in Table 3 are readily explicable, since they occurred when there was a marked shift in the direction of the wind at Hemsby, either in the course of the period in question, or between the surface and 900 m.; while in a few cases when the birds travelled a little north of east with a northerly wind, the wind was very light. Hence, these findings fully support Ritchie's view that the course taken by drifted migrants is the resultant between the heading of the birds and the wind, and they also confirm that migrational drift is exceedingly common, since it occurred almost every day and every night, and there was no difference between the day and the night in its frequency or nature.

This evidence indicates that, when over the sea, the migrants maintained a constant heading by means of their sense of direction (based on the position of the Sun or the stars), but that they did not at all correct for wind drift by that more mysterious capacity by which they 'home'. Their course from

Norfolk varied between north-east and south-east, sometimes on successive nights, so that, according to the night on which they happened to travel, the migrants might make their landfall anywhere between mid-Denmark and Belgium, some 400 miles apart. It is at this juncture, presumably, that their sense of geographical position comes into play. That birds possess such a capacity is shown not only by homing experiments[4,6] but also by the fact that various drifted migrants trapped and ringed in Britain have later been recovered in their normal Continental wintering or breeding grounds well to the east, and Williamson has rightly stressed the importance of such re-directed movements. Indeed, it may be claimed that the homing sense, now demonstrated in many species of birds, is primarily an adaptation to counteract drift, which the present observations show to be a normal accompaniment of migration.

The observations in Table 3 refer to directions over the sea. Many fewer directions were observed over the land in Norfolk, but these followed the same general trends, the birds travelling south of east with northerly winds and north of east with southerly winds. Hence migrational drift also occurs over the land, though if the birds fly lower when over the land than over the sea, their drift will be smaller, since the wind is normally weaker nearer the ground. These remarks, it should be added, refer only to those migrants flying high enough over the land to be detected by radar, and not to those flying low by day, which may follow the coast or other 'guiding lines'.

While, as shown here, migrational drift is regular in fine or moderately fine weather, Williamson and others have found that drifted migrants land in large numbers at the British east-coast bird observatories primarily when they must have met wholly overcast conditions during the course of their journey. Under such conditions, birds can no longer see to navigate by the Sun or stars. Moreover, as is well known, they do not normally set off on their migrations in such weather, hence the spring departure from Norfolk normally provides unsuitable conditions for studying what happens. However, in clear weather on the afternoon of April 17, 1958, many redwings and other species took off rather north of east, and soon after dark, mist and rain became general. Rain echoes came to obscure most of the plan-position display, but one gap remained well out to sea, and here, between 2030 and 2130 hr., I had quite unusual difficulty in establishing the directions of the birds from the afterglow of the echoes. In one period, for example, there seemed to be twenty-one directions scattered fairly evenly between north-north-east and south-east, and eleven others between south-south-west and north-north-west; but the afterglow was normally short, and soon afterwards the directions often seemed to have changed. Yet only three hours earlier, in fine weather, there were many sustained tracks in a nearly constant direction north of east, and the same applied once more when the rain cleared off in the early morning. Presumably, during the period of fully overcast conditions, the birds could not maintain their heading, and flew around irregularly with repeated changes of direction.

It is hoped to study such conditions more fully later; but provisionally the radar evidence suggests that migrants meeting fully overcast skies over the sea fly around irregularly and indecisively, in which case their eventual direction will be that of the wind at the time. Further, they are likely under these conditions to become extremely tired, and so will tend to alight at the first land encountered. With normal drift in fine weather, on the other hand, migrants reaching the coast seem usually to proceed some way farther before settling, and so are not concentrated at the point of arrival. Hence it is primarily when migrants meet overcast conditions that they later appear in large numbers at the British bird observatories.

I am extremely grateful to the Air Ministry and to the Research Branch, Fighter Command, for allowing me full facilities for this work, and to Mr. W. G. Harper, of the Meteorological Office, East Hill, who is also working on birds and radar[7], for most helpful discussions. The pioneer work in this field of E. Sutter[8] was an invaluable spur.

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[6] Matthews, G. V. T., "Bird Navigation" (Camb. Univ. Press, 1955).
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OBITUARIES

Prof. C. H. Desch, F.R.S.

No one could come in contact with Cecil Henry Desch, who died on June 19 at the age of eighty-four, without being influenced by his astounding knowledge and complete sincerity. Educated at Birkbeck School, Finsbury Technical College and University College, London, as a chemist, he then went to Würzburg, where he obtained his doctorate.

After being connected with the brewery and cement industries for a short time, he joined the Metallurgical Department of King's College, London, in 1902, and it was during this time that much of the work on his book on "Metallography" was done. In the preparation of this volume he was greatly indebted to Mrs. Desch for the preparation of the beautiful microsections with which it was illustrated. The influence of this book on English metallurgy was immense. In many ways it broke new ground, and it may be that this represents his greatest influence on metallurgical science, in any event in Great Britain.

In 1909, Desch was appointed to the Graham Young lectureship in metallurgical chemistry in the University of Glasgow, remaining there until the end of the First World War, when he was appointed to the chair of metallurgy at the Royal Technical College in that city. His tenure of this chair was short (1918–20), and on the retirement of Arnold he succeeded him in the chair of metallurgy in the University of Sheffield. His twelve years in this chair saw immense changes and the beginning of the modernization which was inevitable if its reputation was to be maintained, and it was during this time that I knew him best. It was not an easy job to follow Arnold and to make the changes in the existing course which Desch saw to be essential, and those in closest scientific contact with him must have wondered whether this post was really congenial.

In 1932 he resigned his chair, to follow Rosenhain as superintendent of the Department of Metallurgy at the National Physical Laboratory, remaining there until his retirement, in 1939.

Desch's next appointment must have surprised most of those who knew him, for in the November of that year he was appointed, by Securities Management Trust Ltd., to the board of Richard Thomas and Co., Ltd. In 1943 he resigned, on appointment as chief scientific adviser to the Whitehead Iron and Steel Co., Ltd. This complete change from academic to industrial life, however, seemed to give him real satisfaction. It was not his first experience of industry, and the possibility of applying his wide knowledge to the industrial needs of the country at a critical time was compatible with his life-long interest in sociological problems. These had, I believe, at an earlier date led him to become somewhat republican in his political thought, though this changed later, when he again became (mildly) royalist.

Desch's quite outstandingly successful book on metallography was followed, in 1914, by one on "Intermetallic Compounds". Despite all the changes which have taken place in the intervening years, this is still a book which may be read with profit, and was, when first published, of the greatest interest. In addition, and largely as a result of the visit paid, in 1931, to the United States of America, where he was the George Fisher Baker Lecturer at Cornell University, he published one of the earlier books on the solid state, the "Chemistry of Solids", largely based on the lectures which he gave there.

Over a number of years he was greatly interested in early metallurgy, as a result of which a number of reports were submitted to the British Association on the source of metals used by the Sumerians and other ancient peoples.

Elected to the Royal Society in 1923, he was president of the Faraday Society during 1926–28 and received the Bessemer Gold Medal from the Iron and Steel Institute and the Platinum Medal of the Institute of Metals, both the highest distinctions which these Institutes have it in their power to confer.

It was as a teacher, however, that Desch probably reached his highest level. He was an excellent lecturer, and the width of his knowledge enabled him to weave together facts and ideas obtained from an almost unique variety of sources. His mind was not strikingly original and his researches in metallurgy did not make any very lasting mark on its development.

This account of his scientific life and the important posts which he held gives, however, an inadequate description of the man himself. His complete sincerity of thought and his interest in human needs in general have already been mentioned. Among his relaxations was his interest in geology, a fact which led to his very good Sorby Lecture, delivered in 1921. His somewhat shambling gait was characteristic, but it carried him over many miles of rough country.

F. C. THOMPSON

Mr. H. E. Balch

MR. H. E. BALCH, honorary curator of the museum at Wells, Somerset, for sixty-one years, died on May 27 at the advanced age of eighty-eight.

Starting life as a messenger in the Post Office and finally rising to the position of head postmaster at Wells, he devoted the whole of his leisure time to the exploration of the Mendip Hills, and this in spite of the long hours of duty involved in his work. In 1893 he started a museum of his own material in the West Cloister of Wells Cathedral. An ardent collector himself, he soon persuaded others to give, and in 1928, through the generosity and interest of Mr. William Wyndham, the Museum was moved to a large house in the Cathedral Green. He was made chairman of the Trustees for life and honorary curator, a position he held until his retirement in 1954.

Balch had many publications to his credit, his major work undoubtedly being the large monograph on the excavations at Wookey Hole. He was awarded the honorary degree of master of arts in the University of Bristol in 1925 and was presented with the freedom of the City of Wells in 1944. He will be remembered with affection by many for his devotion and zeal to the elucidation of the problems of Mendip and for the amassing of such valuable collections which now and for the future will form the basis of the important museum at Wells. F. S. WALLIS

NEWS and VIEWS

Ministry of Supply Electronics Research and Development (Telecommunications): Mr. R. G. Friend

MR. R. G. FRIEND, who has been appointed director of electronics research and development (telecommunications) in the Ministry of Supply, read physics at Queens' College, Cambridge, where he was a Foundation Scholar and took first- and second-class honours in the two parts of the Natural Science Tripos. He then joined the Research Department, Woolwich Arsenal, where for some years he was engaged on research on X-ray and magnetic methods of material testing. In 1935, he transferred to the Air Defence Experimental Establishment for acoustical research with particular reference to the development of a new sound locator using electrical delay lines. Early in 1939, Mr. Friend was selected to move to Bawdsey to join a small team working with Sir Robert Watson-Watt on the application of the new radar techniques to Army problems. On the outbreak of war, this team moved to Christchurch, where it expanded and ultimately became the Radar Research and Development Establishment. Throughout the Second World War, Mr. Friend continued in this work and was responsible for many contributions in the fields of radar fire control for anti-aircraft guns and of counter-measures to radar jamming. He was for some years in charge of the Fire Control Group and later the Basic Techniques Research Group. In 1954 he moved to the headquarters of the Ministry of Supply on appointment as assistant director of electronics research and development. In this post, and later as acting director, he has been responsible for the research and development aspects of all ground radar for both the R.A.F. and Army applications.

Armament Research and Development Establishment : Dr. D. H. Black, C.M.G.

Dr. D. H. Black, who has been appointed director of the Armament Research and Development Establishment of the Ministry of Supply, in succession to Mr. E. McEwen, was born in 1899 in New Zealand, where he received his early education, taking first-class honours in physics at Canterbury. He came to Britain to work under the late Lord Rutherford in the Cavendish Laboratory, Cambridge, in 1923, gaining his Ph.D. in 1925. Dr. Black spent some fourteen years in industrial research with Standard Telephones and Cables, ultimately as head of the Valve Laboratory, before joining the Government service in September 1939, when he was appointed superintendent of the then Air Defence Experimental Establishment. In 1943, he was seconded to the Admiralty for special liaison duties in the United States, mainly concerned with new valve and electronic developments for radar and communications. He returned in 1945 as superintendent in charge of research at the now renamed Radar Research and Development Establishment, and in 1947 he moved to the headquarters of the Ministry of Supply, becoming director of electronics research and development in 1949. In 1953, Dr. Black was appointed head of the U.K. Ministry of Supply mission in Australia. During his three years in this post, the interests of the Ministry in Australia expanded considerably with the development of the guided weapon and atomic trials at Woomera and Maralinga. For his work in this post Dr. Black was appointed C.M.G. On returning to England in 1956, Dr. Black was appointed director-general of electronics research and development at the Ministry of Supply headquarters. Widely known in electronics and scientific circles, his appointment as head of the Armament Research and Development Establishment is indication of the increasing importance of electronics in all branches of armaments, as well as of his own personal and scientific strength.

British Scientific Instrument Research Association : Mr. R. J. Bracey

Mr. R. J. Bracey, head of the Optical Department of the British Scientific Instrument Research Association, will retire on July 31, after thirty-three years of service with the Association—and forty years of service to the optical industry. While still a boy, Bracey developed a deep interest in mathematics and a desire to apply his mathematical gifts to optical design, and after working for six years for a firm of shipbrokers and in a bank, he joined the firm of R. and J. Beck, the microscope makers. There he worked for the next seven years, in the shops and as a designer, until 1924, when Sir Herbert Jackson, then director of the British Scientific Instrument Research Association, invited Bracey to join the staff. Bracey's work during the next thirty-three years is reflected in the thirty-six research reports which bear his name or signature, twenty-four of them concerned specifically with optical design. Microscope objectives, including pioneering systems for ultra-violet microscopy; optical systems for telescopes; illuminators; focometers for spectacle lenses; systems of ray tracing; lens and mirror systems; interferometers; collimators; the optics of clinical thermometers; the examination of bearing jewels—Bracey's field has been wide. The $f/0{\cdot}36$ object-glass designed by Bracey for stellar spectroscopy at the Mount Wilson Observatory is one of his most important designs. Bracey's long service to the industry will not end with his retirement. It may be, indeed, that one of his greatest services is still to come, because the monograph on optical design which he is now writing and will complete in retirement may well prove to be an outstanding contribution to the literature of the subject. His services as a consultant will still be available to the Research Association.

Mount Wilson and Palomar Observatories : Dr. W. Baade

Dr. Walter Baade, who has been a member of the staff of the Mount Wilson and Palomar Observatories for twenty-seven years, is to retire. Dr. Baade, who was born at Schroettinghausen, in Germany, received his Ph.D. in 1919 at Göttingen and the same year was appointed to the staff of the Hamburg Observatory, where he remained until he received his appointment to the staff of Mount Wilson in 1931. Dr. Baade is noted for his discovery that two entirely different types of stars (Populations I and II) exist. This led to his recalibration of Cepheid variable stars in the Andromeda nebula, and his correction of the cosmic-distance scale. His work, which was reported at the International Astronomical Union meeting in September 1952, indicated that all objects beyond the Milky Way are about twice as distant as had previously been supposed. He has also collaborated with Dr. Rudolph Minkowski in the identification of celestial radio sources with visual objects, and in the physical interpretation of the nature of these sources. In 1954, Dr. Baade was awarded the Gold Medal of the Royal Astronomical Society, "for his observational work on galactic and extragalactic objects".

The Warren Spring Laboratory

The new Department of Scientific and Industrial Research Laboratory, now being built at Stevenage, will be called the Warren Spring Laboratory. The name is taken from a lane that used to run across the site on which the laboratory is being built. The Council for Scientific and Industrial Research has expressed the view that the Warren Spring Laboratory should be a versatile station, free to do work on any subject which becomes important for the nation and which cannot be fitted into the programme of another research body. It has already been decided that work will be carried out on air pollution; on the synthesis of oil and chemicals from carbon monoxide and hydrogen; and on mineral processing. The new station will, in addition, be free to take up any research requiring staff and facilities of the type that are being provided. Mr. S. H. Clarke, director of fire research, Department of Scientific and Industrial Research, has been appointed director of the Warren Spring Laboratory.

International Inspection of Nuclear Power Plants

A question was asked in the House of Commons on July 10 as to whether Britain would make it a condition of supplying civilian nuclear power plants to Brazil, Germany, Spain and other countries that continuous inspection should be undertaken by the International Atomic Energy Agency. The Prime Minister replied, pointing out that the Agency has not yet worked out methods for implementing the inspection and other safeguard provisions in its governing statute. All that can be done is to specify in the contracts the right of supervision by the appropriate international agency. Contract orders placed this year, which will not operate before 1961 or 1962, will enable the Government to insist upon whatever methods of inspection seem proper and desirable. Mr. Macmillan also pointed out that the Agency is a board of twenty-three governors from as many countries with somewhat different approaches to this matter and that it may be difficult to get such a board to agree to adopt a particular form of technical operation. If it cannot be done in one particular way there may be some other agency or method for securing effective control; we have perhaps three or four years in which to work out the best method.

Nuclear Reactor for Winfrith Heath

In a written answer in the House of Commons on July 8, the Prime Minister said that it has been decided on technical grounds that the homogeneous aqueous reactor system planned for Winfrith Heath is not at present suitable for a major research and development effort, either by the Atomic Energy Authority alone or as a joint programme under the European Nuclear Energy Agency. Discussions are now in progress in the Agency about a joint research programme on the high-temperature gas-cooled reactor, a system which holds considerable promise for generating power but which has not yet been investigated in detail. This would include the construction of an experimental reactor in the United Kingdom, and Mr. Macmillan hoped that a satisfactory agreement will be concluded in the next few months. On the same day it was stated that the British Government contributes about one-quarter to the total budget for 1958 of £4,660,000 of the European Organization for Nuclear Research.

Research in the Aircraft Industry

The debate on the aircraft industry, which was opened by Viscount de L'Isle in the House of Lords on July 16, is of interest for the consistent emphasis laid on the importance of research by almost all speakers. Lord de L'Isle said that the industry is one of three or four in Britain in which it is vital to the national economy that it should gain and maintain a leading position in the world, and added that in this industry the demand to plough back money in research and development is the most insistent; he put the necessary figure at 20–30 per cent of turnover. Lord Ogmore, who asked again for an independent inquiry into the structure and situation of the industry, questioned whether it was possible to provide finance for research and development necessary for supersonic airliners from non-military sources alone, and said that about six of the 200 firms in the industry are responsible for 80–90 per cent of the output. The Earl of Swinton, urging that it is the duty of the Government to have a definite policy of development and to make this plain to the industry, argued firmly that we cannot afford to skimp expenditure on research, while Lord Adrian, pointing out that the aircraft industry is in the forefront of technological progress, said that there is scarcely any field of technical advance which did not receive an immense stimulus from war-time developments in aircraft. Instancing radio, metallurgy, engine design, electronic control and almost every kind of fine engineering, he said that the problem is whether we could afford to lose the technology which would go into the planes no longer required for defence, since it would be applied to machines and have just as much influence on industrial development as many developments in nuclear energy. The value of the applied research required for building a full-scale machine was not easily over-rated, and Lord Adrian believed that an important case can be made for Government sponsorship of the design and construction of some advanced machines. Viscount Caldecote strongly supported Lord Adrian's plea, pointing out also the vital need for continuity in research and suggesting allocation of finance for research and development over a five-year period: research cannot be stopped and restarted. He also supported Lord Weeks in a plea for clear guidance to the industry from the Government in policy. Lord Pakenham advocated the formation of a board in the Ministry of Supply, including industrial representation from outside the aircraft industry. Lord Mancroft, in reply, agreed as to the vital importance of research, but added little to the Minister of Supply's statement in the House of Commons on May 22 in reaffirming that the Government would continue to support the basic research necessary for the industry to survive, both in Government establishments and in industry, and that this would include the construction of research aircraft.

The Clean Air Act, 1956

As from June 1, 1958, the Clean Air Act, 1956, much of which has been in operation since the beginning of 1957, is fully in force, and it will be an offence punishable by fine to emit 'dark smoke' (defined as as dark or darker than shade 2 on the Ringelmann Chart) from any chimney in England and Wales. The ban on dark smoke applies to all buildings, and to railway engines and ships, but it will chiefly affect industrial and commercial premises, and the Minister of Housing and Local Government has issued a Memorandum on the Industrial Provisions (pp. 20. London: H.M. Stationery Office, 1958. 1*s*. net) to assist local authorities in administering these provisions of the Act. It directs attention to certain allowable defences and emphasizes the economies in fuel which can result from measures to reduce smoke. Surveys of Lancashire boilers carried out in 1956 by the National Industrial Fuel Efficiency Service indicate that adoption of measures to improve fuel efficiency on the 18,000 boilers in regular use should offer a saving of 3 million tons of coal a year against a capital expenditure of not more than £14 million. The Act also requires steps to be taken to reduce the emission of grit and dust from industrial chimneys. New furnaces installed after June 1 for burning pulverized fuel or more than 1 ton per hour of other solid fuel must be fitted with grit- and dust-arresting plant approved by the local authority.

European Agricultural Aviation Centre

A European Agricultural Aviation Centre has been set up under the auspices of the European Productivity Agency of the Organization for European Economic Co-operation, with headquarters at The Hague. Its task is to promote co-operation and efficiency in agricultural aviation in Europe and to act as a co-ordinating centre for the dissemination of information and the stimulation of research and development in this field. The need for such a centre has long been apparent in agricultural, industrial and scientific circles. The special type of aircraft used in the application of crop-protection chemicals, fertilizers and seeds are expensive to construct and operate, and to pay their way must be employed to the full during the short season when they are required. This should be possible by operational pooling of the 200 aircraft available and by their use on a south-to-north basis following the seasonal advance. By promoting co-operation on a European scale, these aircraft can be used more efficiently and offer an invaluable adjunct to normal farming methods. During the first two years of its existence, the European Agricultural Aviation Centre will be supported financially partly by the European Productivity Agency and partly by the Dutch Ministry of Agriculture, Fisheries and Food; liaison officers in the participating countries (Denmark, France, Germany, Italy, the Netherlands, Sweden, the United Kingdom, Spain and Yugoslavia) will co-operate in its work. At the end of this period it is anticipated that the agricultural and industrial concerns which benefit from its work will contribute to the Centre's continuation and development, together with interested governments.

An Existing Cœlacanth, *Latimeria chalumnae*, in the British Museum (Natural History)

The first specimen of an existing cœlacanth fish, *Latimeria chalumnae*, to reach Britain has been placed on view in the Fish Gallery of the British Museum (Natural History), London. It was brought over by Prof. Jacques Millot, director of the Institut Scientifique de Madagascar, together with a plaster cast of an earlier specimen, and presented to Sir Gavin de Beer, director of the Museum, to mark the occasion of the Fifteenth International Congress of Zoology. Cœlacanth fishes have a particularly long and interesting history. They are found as fossils in rocks laid down during the Devonian period, indicating that they were in existence some three hundred million years ago, and closely related fossils have been found in many parts of the world, including Europe, throughout the succeeding two hundred and thirty million years. None was known in any formation more recent than the Cretaceous, and cœlacanths were thought to have been extinct for the past seventy million years. In 1938, a large steel-blue fish with many extraordinary features, caught off the coast of East Africa, was identified by Prof. J. L. B. Smith, of Rhodes University, Grahamstown, as a living member of this ancient group. It was named *Latimeria chalumnae*, and since then about a dozen more specimens of *Latimeria* have been found.

Advertising

Lord Heyworth's address at the annual general meeting in London of Unilever, Ltd., on April 24, has been reproduced for private circulation under the title "Advertising" (pp. 17. London: Unilever, Ltd., 1958). In 1957, Unilever spent on advertising £83 million, nearly half in North America alone, and Lord Heyworth defends advertising as a prerequisite to real democratic freedom of choice and an aid to 'progress'; he also suggests that it promotes both the development of new products and their establishment on a more predictable basis. Particularly in the field of what economists term 'consumer durables', such as motor-cars, television sets and refrigerators, but also with soap powder and margarine, Lord Heyworth thinks that advertising brings savings to set against its cost. He refers briefly to the most recent means of advertising—television—and claims that in Britain it has provided an efficient means of communicating with consumers which has been welcome. Finally, Lord Heyworth emphasizes the need for market research, to enable the producer not only to give the customer what she wants but also to find out what she will want in the future.

National Parks in South Africa

The Board of Trustees of the National Parks of the Union of South Africa has under its care five parks: the Kruger (7,340 sq. miles), Kalahari Gemsbok (8,050 sq. miles), Addo Elephant (26·5 sq. miles), Mountain Zebra (5·8 sq. miles) and Bonithole (2·8 sq. miles). Opportunities for research in these vast spaces are tremendous and much fruitful work has already been accomplished. To allow its investigations to become as widely known as possible, the Board of Trustees has launched a new journal devoted entirely to descriptions of work done in the National Parks (*Koedoe*, No. 1, 1958. (Journal for Scientific Research in the National Parks of the Union of South Africa.) Pp. 200. Published annually. Pretoria: National Parks Board of Trustees, 1958). Most of the articles are in English, while the few in Afrikaans have English summaries. Among the outstanding articles is a culicine mosquito survey of the Kruger National Park, some aspects of animal ecology in the Kalahari, and ancient and recent observations on hyænas. The journal has got off to a good start and deserves encouragement.

New Psychological Periodicals

Vita Humana (International Journal of Human Development. Vol. 1, No. 2, 1958. Pp. 65–128. Published quarterly. Basel and New York: S. Karger, 1958. 38.50 Swiss francs for 1 volume consisting of 4 numbers) is a new journal of human biology. It will be concerned principally with the psychological aspects of development, having particular regard to the maturation of behaviour in childhood and to changes in human performance with advancing age. The current part (1, No. 2) contains a report from Birmingham on the psychological status of deprived children and a discussion on the methodology of 'longitudinal research' in the study of human behaviour. The journal is edited by Prof. H. Thomae, of Erlangen, with an international advisory board.

Confinia Psychiatrica (Vol. 1, No. 2, 1958. Pp. 69–132. Published quarterly. Basel and New York: S. Karger, 1958. 38.50 Swiss francs for 1 volume consisting of 4 numbers) is devoted to the borderlands of psychiatry. It will be concerned less with clinical topics than with scientific and philosophical issues having relevance to psychological medicine. Summaries of papers are given in English, French and German. The editors are H. Heimann and Th. Spoerri.

Physical Review Letters

It was announced in the April issues of the *Physical Review* that beginning with the issue dated July 1 the *Physical Review* will no longer carry the feature 'Letters to the Editor', but that the 'Letters' will be published separately in a supplementary fortnightly journal to be called *Physical Review Letters* (1, No. 1, July 1, 1958. Pp. ii+48). The new journal, which includes abstracts of future *Physical Review* articles, will initially be sent free of charge to all subscribers of the *Physical Review*, though from January 1959 onwards a subscription will be charged (to members of the American Physical Society in the United States and Canada, 5 dollars ; elsewhere, 6 dollars ; to non-members in the United States and Canada, 10 dollars ; elsewhere, 11 dollars. Subscriptions should be addressed to the American Institute of Physics, 335 East 45th Street, New York 17, New York). The object of the new journal is to obtain speedy publication and by the use of offset printing to reduce the time between receipt and publication of the letters to two to three weeks. On the average, about fifteen letters will be accepted for each issue and only if they contain important new discoveries or cover topics of high current interest in rapidly changing fields of research.

Government Museum, Madras

THE Administration Report of the Government Museum, Madras, for 1955–56 (pp. vi+60. Madras: Government Printer, 1957), states that following an intensive campaign in publicity, including posters in railway stations all over India, the number of visitors shows a marked increase of 35 per cent over the previous year. Attention has been given to courses in museum technique, and these were held in the natural sciences, archæology, anthropology and chemical conservation. Much routine work has been accomplished in each Department and re-labelling has proceeded in English and Tamil. The Museum has also been very active in its Conservation and Photographic Departments. This work includes the treatment of ancient bronze images by electrolytic methods, and lead coins with dilute acetic acid under control.

Nutritional Requirements

A NEW Food and Agriculture Organization publication (Nutritional Studies, No. 16: Protein Requirements—Report of the F.A.O. Committee, Rome, Italy, October 24–31, 1955. Pp. v+52. Rome: Food and Agriculture Organization of the United Nations; London: H.M. Stationery Office, 1957. 3*s*. 9*d*. net; 0·75 dollars) deals with protein requirements in human nutrition. The report follows two others (No. 5, 1950; and No. 15, 1957), which considered calorie requirements. An attempt is made to assess the needs in terms of a reference high-quality protein (that from milk, eggs or meat). The report briefly discusses basic concepts such as nitrogen equilibrium, essential amino-acids and biological value. The estimated average minimum requirements, in terms of high-quality protein, range from 2·0 gm./kgm. body-weight in infants to 0·35 gm./kgm. for adults. To allow for individual variations in requirement, an increment of 50 per cent is recommended, with a further allowance because the dietary protein will usually be inferior to the reference protein. A section on the practical approach deals with ways of supplementing diets poor in protein and with ways of calculating allowances. An appendix outlines suggestions for further research.

Japanese Laminariaceae

ALGOLOGISTS may be interested to know that the classic monograph "On the Laminariaceae of Hokkaido" (1902), by the late Dr. K. Miyabe, is now available in an English translation (*J. Sapporo Agric. Coll.*, 1, pp. 50, with 29 plates; 1957). The monograph contains a general classification of the family and detailed descriptions of genera and species, with extensive notes on habitat and uses. The beautiful and interesting illustrations, which are a feature of the monograph, are well reproduced.

New Development of Philips Gas Refrigerating Machine

AN addition to the range of the Philips gas refrigerating machine (see *Nature*, 180, 892; 1957) is announced by the distributors, Research and Control Instruments, Ltd. This new machine (the *PW* 7050) incorporates a nitrogen-separation column, by which means air can be liquefied and separated at atmospheric pressure to produce four litres of liquid nitrogen per hour. Continuous operation is possible for a period of one week before de-frosting becomes necessary. Special features of the *PW* 7050 are: fully automatic operation without the need of supervision; small dimensions compared with conventional equipment—the column stands approximately 6 ft. high; risk of contamination is negligible because the air is cooled at atmospheric pressure in a single stage and does not pass through any moving parts. Further information can be obtained from Research and Control Instruments, Ltd., Instrument House, 207 King's Cross Road, London, W.C.1.

Carlsberg-Wellcome Travelling Research Fellowships

THE Carlsberg Foundation (Copenhagen) and the Wellcome Trust (London) announce a second series of awards of the Carlsberg-Wellcome Travelling Research Fellowships which they jointly instituted in 1957 (see *Nature*, 181, 743; 1958). The successful candidates for the academic year 1958–59 are Dr. S. E. Jensen and Dr. D. A. T. Dick. Dr. Jensen, of the Kommunehospitalet, Aarhus, and University of Aarhus, Denmark, will work in Prof. Russell Fraser's Department at the Postgraduate Medical School of London on the factors affecting serum lipoids in man, and Dr. Dick, from the Department of Human Anatomy, University of Oxford, will work with Prof. H. Holter at the Carlsberg Laboratory on the osmotic properties of living cells.

National Research Council of Canada: Scholarships

THE National Research Council of Canada has granted 302 scholarships for the academic year 1958–59, with a total value of 414,700 dollars. These scholarships include ninety-four bursaries worth 1,000 dollars each and 145 studentships worth 1,200 dollars each, all of which are tenable in Canada. Special scholarships awarded for study abroad include forty-six awards worth 2,000 dollars each. These special scholarships are to be held in the following countries: twenty-one in the United Kingdom, twenty-two in the United States, and one each in France, Sweden and Switzerland. Seventeen postdoctorate overseas fellowships, valued at 3,500 dollars for married and 2,700 dollars for single fellows, have been granted for work in the following countries: eleven in the United Kingdom, and one each in Belgium, France, Germany, Italy, Sweden and Switzerland.

Granada Television Research Fellowship

GRANADA TV NETWORK, LTD., has offered a sum of not less than £30,000 to the University of Leeds to be spent over a period of five years in supporting a Granada Television Research Fellowship and in providing the necessary ancillary staff. The offer includes further financial help and the possibility of renewal for a period if these should prove desirable. The purpose of the Fellowship will be to undertake research into the public impact of television over as wide an area of inquiry as practicable—social, æsthetic, political and commercial—and will cover television transmission from any sources in the British Isles. This study is one which will be of interest to a number of departments in the University, including social studies, economics, psychology, philosophy and history.

"Structure of Brain Ganglioside"

Dr. Samuel Bogoch, director of the Neurochemical Research Laboratory and senior psychiatrist, Massachusetts Mental Health Center (Harvard Medical School), has written in connexion with the note under this title published in *Nature*, February 1, p. 314. He states that "his communication under this title published earlier in *Nature* (July 27, 1957, p. 197) referred to previous related work by him (1953–55) from his Harvard doctoral thesis, and described recent work by him done at the Neurochemical Research Laboratory, Massachusetts Mental Health Center, in 1956 and 1957. The latter was supported by grants to Dr. S. Bogoch (principal investigator) from the National Institute of Mental Health and the National Institute of Neurological Diseases and Blindness (U.S.) (Grant No. *M*–1330: grant period June 1, 1956, to May 31, 1957; and Grant No. *B*-1221: grant period November 1, 1956, to October 31, 1957), and not by the American Cancer Society". The Editors of *Nature* have printed these statements from Dr. J. Folch-Pi and Dr. S. Bogoch, but they cannot give further space to the matter.

The Night Sky in August

New moon occurs on Aug. 15d. 03h. 33m. U.T., and full moon on Aug. 29d. 05h. 53m. The following conjunctions with the Moon take place: Aug. 7d. 10h., Mars 1° S.; Aug. 19d. 15h., Jupiter 0·9° N.; Aug. 23d. 08h., Saturn 3° S. In addition to these conjunctions with the Moon, Venus is in conjunction with Pollux on Aug. 10d. 23h., Venus being 6·7° S. Mercury is too close to the Sun for observation. Venus is a morning star, visible low in the south-east before sunrise. It rises at 2h. 10m., 2h. 40m. and 3h. 25m. on August 1, 15 and 31, respectively; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 137 to 149 million miles and the visible portion of the apparent disk from 0·890 to 0·947. Mars rises at 22h. 45m., 22h. 05m. and 21h. 20m. at the beginning, middle and end of the month, respectively. Its stellar magnitude increases during the month from −0·1 to −0·5, its distance from the Earth decreasing from 86 to 70 million miles. Mars continues to move eastwards among the stars, being in Aries throughout the month. Jupiter sets at 22h. 10m., 21h. 20m. and 20h. 20m. on August 1, 15 and 31, respectively; it is near Spica. Conditions for the observation of Jupiter are becoming unfavourable; the planet may be visible low in the west after sunset. Its stellar magnitude is −1·4. Saturn sets at 0h. 35m., 23h. 40m. and 22h. 35m. at the beginning, middle and end of the month, respectively; it is near θ Ophiuchi. It has a stellar magnitude of +0·6 and a distance of 890 million miles from the Earth on August 15. There is one occultation of a star brighter than magnitude 6 visible at Greenwich: Aug. 5d. 00h. 40·5m., 147 B. Psc. (re-appearance). The Perseid meteors are active during the first fortnight of the month, maximum activity being on August 11. Conditions are favourable, the radiant being near R.A. 3h. 04m., Dec. +58°.

Announcements

Miss I. Phyllis Barclay-Smith, secretary of the International Committee for Bird Preservation, has been awarded the Silver Medal of the V. von Heidenstams Foundation in Sweden, for her work on behalf of the preservation of migratory birds. The Medal, which is rarely awarded to foreigners, was presented to Miss Barclay-Smith at Helsinki during the recent Conference there of the International Committee for Bird Preservation.

Mr. F. L. Barrett, of the Bleachers' Association Research Laboratories, Bromley Cross, has been made an honorary member of the Textile Institute.

The third International Neurochemical Symposium, on "The Chemical Pathology of the Nervous System", will be held at Strasbourg during August 25–29. Further information can be obtained from Dr. D. Richter, M.R.C. Neuropsychiatric Research Unit, Whitchurch Hospital, Cardiff.

A meeting on "The Biosynthesis of Phenolic Compounds in Plants", organized by the Plant Phenolics Group, will be held in Cambridge, on September 19, under the chairmanship of Sir Robert Robinson. Further information can be obtained from Dr. T. Swain, Low Temperature Research Station, Downing Street, Cambridge.

The thirteenth Symposium of the Society for Experimental Biology will be held at the University of Reading during September 15–19. The subject is "Utilization of Nitrogen and its Compounds by Plants". Further information can be obtained from the Hon. Symposium Secretary, Dr. J. F. Sutcliffe, 68 Half Moon Lane, London, S.E.24.

The British Society of Rheology is holding a meeting in the Department of Glass Technology of the University of Sheffield during April 15–17, 1959, on "The Rheology of the Glassy State". The meeting will discuss the mechanical and optical properties of inorganic and organic glasses and of high polymers in the glassy state. Intending contributors are invited to submit a title and detailed abstract (400–700 words) before September 15 to Dr. D. W. Saunders, British Rayon Research Association, Heald Green Laboratories, Wythenshawe, Manchester 22. Complete manuscripts will be required by mid-January 1959.

The third Congress of the Italian Society of Nuclear Biology and Medicine, arranged by the Medical Clinic of the University of Florence, will be held in Florence on November 3 and 4. All inquiries and applications for registration should be addressed to the Conference Bureau, Clinica Medica, Centro Radioisotopi, Viale Morgagni, Firenze, before September 15. Titles and short abstracts of papers (about 200 words) should be submitted before that date to the Segreteria della Società Italiana di Biologia e Medicina Nucleare, Clinica Medica, Pisa. The papers accepted will be published in a special issue of *Minerva Nucleare*.

BICENTENARY OF BOSCOVICH'S "THEORIA PHILOSOPHIÆ NATURALIS"

A MEETING was held on June 10 in the Yugoslav Embassy in London, at the invitation of the Ambassador, with Sir Harold Hartley in the chair, to celebrate the bicentenary of the publication in Vienna in 1758 of the "Theoria Philosophiæ Naturalis, redacta ad unicam legem virium in natura existentium" of Roger Joseph Boscovich, *S.J.* (born Ragusa, 1711; died Milan, 1787). The gathering represented many sciences and nationalities, reflecting the wide interests of a great eighteenth century figure.

Sir Harold Hartley opened with a brief sketch of Boscovich's relations with England and the Royal Society, of which he was made a Fellow on January 15, 1761, the same day as Sir Joshua Reynolds. Boscovich paid a visit to England in 1760, meeting many leading personalities, and incidentally served as Ambassador of the Free City of Ragusa, seeking to convince the British Government that Ragusa was not being used as a base by French warships. Sir Harold read a message from Prof. E. N. da C. Andrade describing the warm response of the Royal Society to Boscovich's visit, and of Priestley, Young, Faraday and Kelvin to Boscovich's ideas on the ultimate nature of matter, though the average student to-day may scarcely have heard of him.

Mr. L. L. Whyte then gave an address on Boscovich's theory of fundamental particles. Though Boscovich was recognized by his contemporaries as a distinguished mathematician, astronomer, geodesist, physicist, engineer and architect, as well as poet and diplomatist, his originality and influence were greatest in his "Theoria", where he developed in systematic form his doctrine of the constitution of matter. This was a kinematic theory of point particles[1], in which the traditional dualism (maintained by Newton and all Boscovich's scientific predecessors) of regions of space filled with matter contrasted with empty regions was discarded in favour of the simpler and more powerful 'Pythagorean' conception of spatial patterns of physical points, interacting in pairs in accordance with a single oscillatory law. Boscovich defined the general form of this law of central actions, but left the constants to be determined in the future. His theory was, in effect, a *programme for atomic physics* which a school of physicists has been carrying out since, until de Broglie introduced the wave-particle in 1923. Something might be gained by comparing the complex fields of 1958 with Boscovich's simple particles of 1758. Mr. Whyte showed that the great originality of Boscovich's conception had been recognized, not only by leading British and Continental scientists from 1760 to around 1920, but also by philosophers as varied as Nietzsche, Russell and Cassirer. It was of interest that both Nietzsche and Mendeléeff had put Boscovich with Copernicus as two of the most important and successful challengers of visual appearances.

A series of brief statements were then made on other aspects of Boscovich's work. Prof. Z. Kopal explained that Boscovich's contributions to astronomical science were in keeping with the trend of his times—the main achievements made during his lifetime were not in the field of discovery, but in the application of Newtonian gravitation to the theory of motion of celestial bodies, a work in which Boscovich took a prominent part. He shares honours with Laplace for the development of a method—still in use—for computation of cometary orbits based on three observations. As a professional astronomer for at least a part of his life-time, Boscovich perfected the stellar micrometer and, in 1770, became the founder and first director of the Brera (Milan) Observatory, which has remained in the forefront of Italian astronomical activities ever since.

Mr. C. A. Ronan discussed Boscovich's work in optics. He pointed out that in the eighteenth century corpuscular theories of light were the vogue but that Newton's theory of "easy fits of reflexion and refraction", which had been invoked to explain the partial reflexion and refraction occurring at the boundaries of surfaces of media having different refractive indices, was not fully appreciated. In Boscovich's theory of light the corpuscles were conceived of as rotating and having different polarities on their two sides, one being attracted by matter and the other repelled. Partial reflexion and transmission were thus explained. Moreover, this idea was invoked by others to explain, in conjunction with Boscovich's theory of matter, the penetration of light through solid bodies and the phenomena of astronomical refraction and of phosphorescence. Mr. Ronan also spoke of Boscovich's practical work in the design of an astronomical micrometer, his determination of the instrumental errors of the mural quadrant at Milan, his design of an equilibrium suspension for instruments of this kind, and his discussion of the residual errors inherent in such instruments and their reduction by appropriate design.

Dr. J. F. Scott considered Boscovich's contributions to pure mathematics, passing from his remarkable recognition of the possibility of a non-Euclidean geometry (for example, "these minds . . . would not seek, as our geometricians do, to rectify the parabola; they would endeavour, if one may use the words, to *parabolify* the straight line": "Theoria", § 116) to his advances in trigonometry, his brilliant essay on conic sections, his anticipation of the work of Legendre and Gauss on the calculus of observations, and his importance as one of the earliest foreign scholars to adopt the Newtonian theory of gravitation. Father L. J. Copplestone, *S.J.*, discussed Boscovich's atomism as an illustration of how a theory which is 'philosophical', as possessing wide implications, may provide the basis for a scientific theory which can be put to experimental test.

The Yugoslav Ambassador gave a lively sketch of Ragusa in Boscovich's time, and described how he established the first direct diplomatic relations between the Yugoslav peoples and Great Britain. Prof. I. Supek, president of the Boscovich Institute at Zagreb, brought greetings from the Yugoslav scientific societies and outlined the work of his Institute in research and teaching.

Sir Harold Hartley, in summarizing the contributions, stressed the part that Boscovich had played in establishing relations between the Southern Slavs and the United Kingdom, and the need for a biography of a great scientist recently unduly neglected. A scheme is under consideration for a volume combining a short biography with an extended report of the meeting covering additional aspects of Boscovich's scientific work.

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[1] Recent studies of Boscovich's atomism, interpreting it as a kinematic theory, have been made by Whyte, L. L., *Nature*, **179**, 284 (1957), and *Notes and Records of the Royal Society*, **13**, 38 (1958); and by Jammer, M., "Concepts of Force", 170 (Harvard Univ. Press, 1957).

PHOTOCHEMICAL REACTIONS

THE Society of Physical Chemists of France organized a symposium on the transfer of light energy and photosensitization at the Physico-Chemical Laboratory of the University of Paris during May 27–30. In his introductory remarks, Prof. F. Perrin discussed the general principles of light-energy transfer and the life periods of activated molecules, fluorescence, chain reactions and their inhibition. D. Curie (Paris) presented the theoretical aspects of energy transfer and its mechanism in the crystals of luminescent minerals, such as zinc sulphide and potassium chloride. H. Haken (Erlangen) considered the theory of excitons and their role in the transfer of energy in the solid state. S. Nikitine (Strasbourg) described his experiments on the absorption, emission and reflexion spectra of thin layers of Cu_2O, HgI_2, PbI_2, CuBr, CuCl, TlI, TlBr, TlCl, CdS and CdI_2. Some experiments on the transfer of energy by excitons in cadmium sulphide were reported by E. Grillot (Paris), and N. Arpiarian (Paris) discussed the luminescence of zinc sulphide activated by gold and nickel at − 158° C.

A series of papers on the luminescence and energy transfer by organic compounds such as benzene, naphthalene, anthracene, chrysene, pyrene, dihydrodiphosphopyridine nucleotide, etc., were presented by workers from several countries. Other topics included the spectra of silver halides and the phenomena of optical sensitization and desensitization; photo-oxidations and photo-reductions and fluorescence of different organic compounds, colouring matters and their acceleration and inhibition; the transfer of light energy, fluorescence and mechanism of plant and algal photosynthesis. N. R. Dhar and co-workers (Allahabad) discussed their investigations on the increase of nitrogen fixation in soils on incorporating molasses, straw, grass, leaves, etc., by light absorption and calcium phosphates. The mechanism of this nitrogen fixation is based on the decomposition of water molecules into H and OH as in plant photosynthesis. As in animal metabolism and photosynthesis, phosphates are of great importance in nitrogen fixation. A. Szent-Györgyi (Massachusetts) contributed an important paper on the transfer of energy in muscles. This transfer is possible to distances greater than atomic dimensions.

As the world as a whole is short of food, intensive investigations on the acceleration of photosynthesis and soil nitrogen fixation are bound to be of great practical value.

On May 31 the Society celebrated its fiftieth anniversary at the Maison de Chimie, and addresses dealing with the progress of physical chemistry with special reference to France were delivered by Profs. R. Lucas, E. Bauer, R. Wurmser and A. Szent-Györgyi and the representative of the Minister of National Education in France.

THE GERMAN STARCH CONVENTION, 1958

THE International Starch Conference, held at Detmold during April 22–24, was well attended, with some 200 delegates from twenty countries.

In the section covering research and analysis, a paper was read by Dr. G. Gilbert (Birmingham), in which the action of air on aqueous solutions of starch was surveyed. An estimate has been made of the rate of hydrolysis of starch by pure water at 100° and 120° C., and it is found that the molecule of amylopectin is large enough to be affected by such hydrolysis during the dispersion of starch. The molecule of amylose, however, is too small to be affected by such hydrolysis, and it was suggested that oxidation by air contributes to the variation in the published values of the molecular weight of amylose. It was found possible to fractionate starch by dispersing it in cold sodium hydroxide under nitrogen and centrifuging the dispersion. Although sodium hydroxide is usually regarded as a good solvent for starch, the bulk of amylopectin was found to be quite insoluble in it under anaerobic conditions.

The development and present state of the starch industry in the United States was discussed by Dr. G. E. Hilbert (Washington). He reported recent success in growing a variety of maize, the starch from which contains 82 per cent amylose. It is hoped to raise this proportion to more than 90 per cent in the future. Amylose thus produced is cheaper than that obtained by chemical fractionation of starch. It is converted to the acetate, which is similar to cellulose acetate, and, moreover, it can also be digested in the stomach. Amylose acetate is therefore used for the production of such foodstuff adjuncts as sausage skins. Another development in the United States is the electrolytic oxidation of starch with periodic acid; the dialdehyde obtained is a good tanning agent for skins and is also used as a base for plastics.

Prof. M. Samec (Ljubljana) read a paper concerning the degradation of starch by γ-radiation. He reported in particular on the effects of the radiation derived from the betatron, X-rays and cobalt-60 on potato starch. Irradiation by cobalt-60 for 3 hr. was found to cause in starch complete loss of power to adsorb iodine. After 5 hr. the dialysable fraction had risen to 5·2 per cent and the reducing power had increased three-fold. After 7 hr. irradiation by cobalt-60, a dispersion of starch in water was reduced to nearly the same viscosity as pure water. It was also found that the amylopectin fraction had acquired an acid *p*H.

It has been known in the confectionery trade that starch syrups, made by acid hydrolysis of starch, tend to become 'brittle' and cloudy when containing a high proportion of dextrose. Dr. G. Graefe (Hamburg) informed the meeting that stable syrups of low monosaccharide content can be produced by using initial starch dispersions of high concentration. The hydrolysis is carried out in two consecutive stages: first using acid to dextrose-equivalent 50, followed by treatment with malt enzyme.

The ion-exchange properties of freshly prepared and aged starch with heavy water have been studied by M. Čeh (Ljubljana). He reported that the rate of exchange of hydroxyl groups of amylose and amylopectin with heavy water (D_2O) has been measured by means of infra-red spectroscopy on dried films. It was found that the capacity to exchange ions of aged amylose films is much smaller than that of fresh films, whereas amylopectin similarly treated undergoes no change. Treatment of aged amylose films with potassium hydroxide or hot water restores the capacity to exchange with heavy water almost to its former value.

A. W. Davies (London) discussed the production of vital gluten and its application in Great Britain. Vital wheat gluten fulfils a useful function in the fortification of flour or bread doughs, on which it confers increased volume, improved crumb structure, keeping quality and flavour, while enhancing its nutritional value. It permits the manufacture of bread suitable for inclusion in diets prescribed in the treatment of certain clinical conditions. Gluten, at one time considered only a waste product, is rapidly becoming indispensable to the baking industry.

At the conclusion of the conference a meeting was held to discuss the project for standardizing the analysis of starch and its products on an international level. Work has already been started by ten committees covering such items as viscosity, ash, colour and protein content of starches. It was resolved to ask the International Organization for Standardization to take this project under its ægis and to organize further work in the many countries interested in it.

E. DUX

THE WOOL INDUSTRIES RESEARCH ASSOCIATION

REPORT FOR 1957–58

THE report of the Director of Research of the Wool Industries Research Association for 1957–58*, presented at the thirty-ninth annual general meeting on March 25, notes that the increase in the statutory levy obtained by the Wool Textile Research Council and the Wool Textile Delegation has enabled the Association to obtain a maximum grant from the Department of Scientific and Industrial Research. Work at Torridon on behalf of the Technical Advisory Committee of the Federation of British Carpet Manufacturers on the relative merits of East Indian, New Zealand and British wools for carpets has shown that East Indian wools may have a density as much as 30 per cent less than that of New Zealand wools because of the presence of medullated or hairy fibres. Wear tests of an experimental carpet indicate that the abrasive machines used by the Association correctly assess the results likely to be obtained in actual wear. The Association has accepted a sponsored project which aims at combining the Association's shrink-resistant process with some method of stabilizing the fibre, so that the shape as well as the size of the garment will be retained after washing.

Experience with the pilot scouring machine has emphasized the need for a more versatile set for research. The study of the effect of the nature and amount of residual grease from scouring, together with added oil, on breakage of fibres and subsequent tear on combing points to the possibility of considerable improvement. Trials at Torridon have substantiated the claims of some firms that special fancies can reduce the amount of fettling, but a very solid foundation of fettlings may be built up, removal of which is difficult without damaging the cloth. It is now reasonably certain that the region of high twist occurs in the short portion of yarn between the delivery rollers and spindle tip when the carriage is at its innermost position. This short length is twisted twice on successive draws and the double twisting is not completely removed before the yarn is wound on the top. Accordingly, reducing the length of yarn at the innermost position may be advantageous. Sintered metal bearings for mule spindles impregnated with polytetrafluoroethylene have performed very well under test and are being tried in the mill.

The Raper auto-leveller draw-box is being modified for use with the rotating can method to permit a greater output and larger packages from the draw-box. Considerable progress is reported in the analysis of spinning end-breaks, and extensive experiments have been made to determine whether the 'resting' of wool at different stages in processing contributes to any desirable qualities in the finished fabric. Scouring experiments have been completed with white worsted and fancy woollen pieces, and special scouring routines have been developed to overcome difficulties experienced with wool 'Terylene' worsted cloths, while light bars and streaks in these cloths have been traced to exposure to light before scouring, when the oxidation of the combing oil is accelerated, and this is more readily removed from 'Terylene' as its state of oxidation advances. A survey of crabbing routines in the mills of twenty-three firms was completed, and in the Scottish Laboratory a study of the effect of steaming and storage on wool oils emphasized the importance of tryptophan in the discoloration of wool. Experiments at the Rowett Research Institute on the effect of a light–dark rhythm on the growth of wool indicated a seasonal variation in production of the wool, although the sheep were provided with a constant diet and maintained indoors. New methods have been applied to the fractionation of the soluble fractions and those precipitated iso-electrically from oxidized wool, and an apparatus was designed for following detergent action under the microscope, and another constructed for studying the visco-elastic properties of wool fibres over five decades below 1 cycle per second, under controlled conditions of temperature and humidity. Working at very high dilution to minimize association, infra-red spectroscopy has shown that both phenol and pyrrole react with the CO group of the secondary amide N-*n*-butylacetamide in carbon tetrachloride as solvent, and combination of neither compound with the amide modifies the infra-red absorption band of the amide NH group.

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* Wool Industries Research Association. Report of the Director of Research for 1957–58. Pp. 30. (WIRA Publication No. 211.) (Torridon, Headingley, Leeds: Wool Industries Research Association, 1958.)

In his chairman's address at the annual general meeting, Mr. John Foster Beaver, reviewing changes in the circumstances and outlook of the Research Association, after a reference to its pioneering work on the control of relative humidity and on the fundamental properties and modes of operation of materials and processes used in the industry, said that the problem to-day was rather the significance for individual processing of the new knowledge being obtained from many other sources also. The Research Association had accordingly departed considerably from concentration on long-term research and was paying more attention to the immediate needs of the industry. During the past year more than 1,500 reports on consulting work were sent to members, and apart from solving an immediate difficulty, such reports indicate more general lines of research. For example, consulting work on stripey and barry pieces had led to an extensive programme on the effect of winding, warping and weaving tensions on the appearance of fabrics, which had indicated the degree of control required in these processes. During the year a series of six industrial lectures were given at Torridon on Saturday mornings as a new means of liaison with industry, and the attendance at these lectures had been extremely good.

THE PRODUCTION ENGINEERING RESEARCH ASSOCIATION

THE new building of the Production Engineering Research Association of Great Britain was formally opened by the Right Hon. Lord Chandos, at the Melton Mowbray, Leicestershire, headquarters of the Association on July 3.

These new premises—which have cost £250,000, of which £100,000 has been contributed by the Department of Scientific and Industrial Research—comprise extensive workshops and laboratories for the investigation and development of production engineering techniques. They house machine-tools, recording and testing instruments and auxiliary equipment worth some £500,000.

The acquisition of these facilities constitutes a major stage in the development of the Association, which had been working in temporary accommodation —converted stables—since it was founded in 1946. The Association was sponsored in its initial stages by the Institution of Production Engineers, the Gauge and Tool Makers' Association, the Machine Tool Trades Association, the National Federation of Engineers' Tool Manufacturers and the Department of Scientific and Industrial Research, and had its origin in the Institution of Production Engineers' Research Department which was established at Loughborough College in 1939 under the direction of Dr. G. Schlesinger, formerly of the Technical University of Berlin. Dr. Schlesinger was succeeded by his deputy, Dr. D. F. Galloway, who has been director of research at the Production Engineering Research Association since its foundation.

The Production Engineering Research Association is a non-profit making institution, deriving its income of about £250,000 a year partly from the subscriptions of 640 industrial companies and partly from the Department of Scientific and Industrial Research. It has a staff of about 250, and was established to assist member firms with their particular production engineering problems, undertaking practical investigations in the workshop or laboratory where necessary. Information services and technical training facilities are also provided. Visits are made regularly to each member firm by liaison engineers, members' staff are encouraged to visit the Association's workshops and laboratories, and there is a mobile unit equipped with cinema-cum-lecture theatre, and demonstration bay. A form of associate membership has recently been introduced for technical colleges and universities in Britain and the Commonwealth.

The primary objective of the Association is "to secure economic savings by the prompt and effective application of improved production techniques in members' workshops". One company has been shown how to save about £40,000 a year in the production of a single component; another is saving £30,000 a year by the cold extrusion of electrical components which had previously been produced by machining. Facilities are available for determining the causes of failure of components, for the selection and heat-treatment of materials, for testing lubricants, and for hardness and precision measurement.

But although mainly concerned with the solving of specific problems of member firms, much of the Association's work—particularly on metal-forming and metal-cutting techniques, for which it is very well equipped—is of general interest and application. From the point of view of those engaged in fundamental production engineering research in the universities, one can but regret that the private and confidential consulting nature of the Association's special investigations and development projects prevents the publication of findings which would undoubtedly be of considerable interest and value. Although it is recognized that the Production Engineering Research Association has an obligation to undertake investigations which bring immediate material benefits to the companies that finance its activities, it is to be hoped that as the Association further develops, and particularly in so far as it is a Government-sponsored research unit, the members of its team will be given freedom to initiate, pursue and publicize more work of a more fundamental character.

N. A. DUDLEY

ELECTRONIC COUNTING AND SIZING OF BACTERIA

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THE resistance method of counting and sizing particles in suspension[1] used for counting blood cells[2,3] has been extended to counting and sizing bacteria. This method measures the resistance of a conducting solution as a particle passes through an aperture. For this purpose, a Coulter counter (Coulter Electronics, Chicago) was modified in our laboratory. The original aperture, about 100μ in diameter, was replaced by a smaller one, some 10μ in diameter, through a glass sheet about 50μ thick. The circuitry of the counter was modified to prevent multiple recording of a given cell, and a pulse-height analyser was added to allow a more direct measurement of the distribution of cell volumes. Size distributions for a 4-hr. broth culture of *Escherichia coli*, strain *B*, and for *Bacillus megaterium* spores are shown in Fig. 1. Both suspensions were diluted in 0·1 *N* hydrochloric acid for counting and sizing. Other diluents which have been used are saline, buffers, and nutrient broth. This method of sizing should be applicable to any stable suspension of particles in an electrolyte, provided that the particle conductivity is either less, or only slightly greater, than the conductivity of the solution. It is particularly applicable to sizing biological cells, which have very high specific resistance to direct current.

The resistance method of counting and sizing has the following advantages over optical methods. First, the volume of each particle is measured, rather than some accidental value for an optical cross-section, the latter being a poor measure of particle size for particles of unknown shape. Secondly, in the presence of a background of small particles the signal-to-noise ratio is greater when volume is measured than when a cross-section is measured; the signal-to-noise ratio is further improved by the action of the aperture as a filter for large unwanted particles. Finally, the counter is simple to operate: samples are readily interchanged, and no optical apparatus is needed to view the particles.

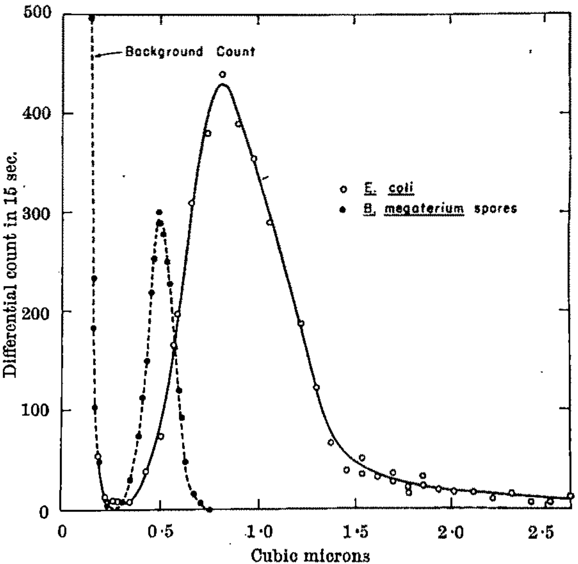

Fig. 1. Volume distribution of cell sizes of *E. coli* and *B. megaterium* spores

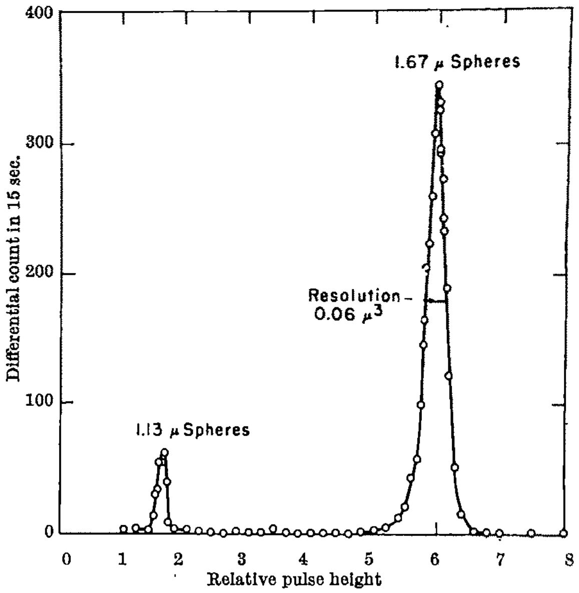

Fig. 2. Relative pulse-height distribution obtained with a mixture of 1·13μ and 1·67μ polystyrene spheres

To test the accuracy of counting, polystyrene latex spheres (kindly supplied by Dr. John Vanderhoff, Dow Chemical Co.), 1·13μ and 3·2μ in diameter, were suspended in saline and counted visually with the aid of a hæmocytometer to obtain absolute counts. The results were compared with values obtained with the counter. Corresponding determinations agreed within the standard error of 2 per cent of the mean. The counter is, therefore, an instrument for absolute counting of spheres at least as large as 30 per cent of the diameter of the aperture.

It can be shown that the change in the resistance of the aperture as a particle passes through it is proportional to the volume *v* of the particle, provided that the greatest cross-sectional area *a* of the particle is sufficiently small (and, of course, that the particle is shorter than the length of the aperture). For example, if the particles are right cylinders of resistivity ρ with axes aligned with the axis of the aperture, and if *A* and *V* refer to the cross-sectional area of the aperture and its volume, respectively, and ρ_0 and Ω the resistivity and the resistance in the absence of particles, then the fractional change in resistance of the aperture due to a single particle is:

$$\frac{\Delta\Omega}{\Omega} = -\frac{v}{V}\frac{\Delta\rho}{\rho}\left(1-\frac{a}{A}\frac{\Delta\rho}{\rho}\right)^{-1}$$

$$\text{where } \Delta\rho \equiv \rho - \rho_0$$

When $\rho \gg \rho_0$ the change in resistance with respect to volume is linear to 1 per cent for right cylinders with diameters less than 10 per cent of the diameter of the aperture. This restriction upon particle diameter for linearity of sizing will be less severe when the resistivity of the particle is not widely different from that of the solution, and it also will be reduced for particles with variable cross-section. (Particles with indentations are not considered here.)

To calibrate the counter for sizing, the relative diameters of 1·13-μ and 1·67-μ spheres were first determined by optical microscopy and by sedimentation in a sucrose gradient. The sucrose gradient measurements were kindly performed by Dr. John F. Thomson of this laboratory. Then the particles were sized electronically and gave, within 1 per cent, the same volume ratio.

The present resolution in volume determination varies between 0·04 and 0·06 cubic microns, corresponding to a linear resolution of about 2 per cent of the diameter for 1-μ spheres. This resolution is the observed half-width at half the height of the peak of the distribution, as in Fig. 2, observed with polystyrene spheres, which have a standard deviation in diameter of less than 1 per cent. The smallest particle volume which can be measured with the present aperture is about 0·2 cubic microns, as is evident from Fig. 1. This limit is set by the noise generated within the aperture, as well as the lesser noise in the electronic circuitry. The noise generated within the aperture is due to the electric current, to debris and, presumably, to localized heating within the turbulent stream.

This work was performed under the auspices of the U.S. Atomic Energy Commission.

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[1] Coulter, W. H., U.S. Patent No. 2,656,508 (1953).

[2] Brecher, G., Schneiderman, M., and Williams, G. Z., *Amer. J. Clin. Path.*, **26**, 1439 (1956).

[3] Mattern, C. F. T., Brackett, F. S., and Olson, B. J., *J. Appl. Physiol.*, **10**, 56 (1957).

INFLUENCE OF WATER ON THE PHOTOLYTIC DECOMPOSITION OF OZONE

By W. D. McGRATH and PROF. R. G. W. NORRISH, F.R.S.
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EARLY work on the photolysis of dry ozone[1] established that the quantum yield was as high as 6·7 for light of wave-lengths between 2080 and 3130 A. Photolysis by visible light[2], however, always gave small quantum yields, the highest values being between two and three.

The fact that water vapour exerts a strong influence on the photolysis was clearly shown by Warburg and by Forbes and Heidt[3], who found that quantum yields varying from 1·6 to 130 could be obtained when ozone was mixed with water vapour and photolysed by light of wave-lengths 2800, 2540 and 2100 A. Forbes and Heidt were able to show that the quantum yield φ was roughly proportional to $\sqrt{[H_2O]}$. This and other experimental findings can be derived from a simple steady-state treatment of the system described later, involving the assumptions that the concentration of oxygen atoms at any time is small and that they are removed by reaction with water and not with ozone. The initiation reactions can then be represented by the three reactions:

$$O_3 + h\nu \rightarrow O_2 + O \tag{1}$$

$$O + O_2 + M \rightarrow O_3 + M \tag{2}$$

$$O + H_2O \rightarrow 2OH \tag{3}$$

which lead to the propagation reactions discussed below.

The results obtained from the early experiments on wet and dry ozone thus indicated that a chain mechanism is operative in both cases when ultra-violet light is used, and that the chain-length can be much greater when water vapour is present. In the case of the dry ozone, a simple atom chain-mechanism is inadequate to explain these results and it is necessary to invoke an energy chain, involving some form of excited oxygen. Absorption of light by ozone undoubtedly results in the production of one oxygen atom according to (1). For visible light this atom can only be in its ground-state ^3P. At wave-lengths less than 3100 A., however, dissociation can yield $O_2(^1\Delta g) + O(^1D)$. Subsequent reaction of either oxygen atom can then liberate a large amount of energy to produce some form of excited oxygen molecule according to the reaction:

$$O + O_3 \rightarrow O_2^* + O_2 \tag{4}$$

Early workers mostly assumed the excited state to be the electronic $^1\Sigma g^+$, but no direct evidence for this was available[4]. Using the technique of flash photolysis and kinetic spectroscopy, we were able to show that under isothermal conditions, that is, with an excess of inert gas, reaction (4) resulted in the production of vibrationally excited oxygen molecules, rotationally cold and in their electronic ground-states[5]. These molecules have sufficient energy to propagate a chain according to:

$$O_2^* + O_3 \rightarrow 2O_2 + O \tag{5}$$

Although ^3P oxygen atoms in reaction (4) are capable of releasing sufficient energy to account for the highest value of v'' observed (63·2 kcal./mole) the evidence was not conclusive in favouring $O(^3P)$ as responsible for the production of O_2^*.

Our recent work will now be outlined in brief. This, together with considerations of earlier work on the photolysis of wet and dry ozone by ultra-violet light, indicates beyond reasonable doubt that it is the $O(^1D)$ atom which is responsible for the chain-mechanism in both cases.

A very significant fact to emerge from the steady-state photolysis of dry ozone is that, when visible light is used, the value of the quantum yield φ is always small. Values have been obtained, however, between 2 and 3, under certain conditions, indicating that although $O(^3P)$ is not an efficient chain propagator it can initiate chains to a limited extent. This conclusion is supported by the work of Benson and Axworthy[6] on the pyrolysis of concentrated ozone mixtures with oxygen. They claim that the kinetics of the thermal decomposition can be explained without postulating an energy chain, and base their conclusion on the fact that, according to their interpretation, the O_2^* produced in reaction (4) with $O(^3P)$ must lose its excitation more rapidly than it can transfer it to ozone and bring about dissociation.

Using the technique of flash photolysis, outlined in a previous paper[5], we have now been able to show that absorption due to oxygen with v'' up to 17 can be detected immediately after dissociation of dry ozone

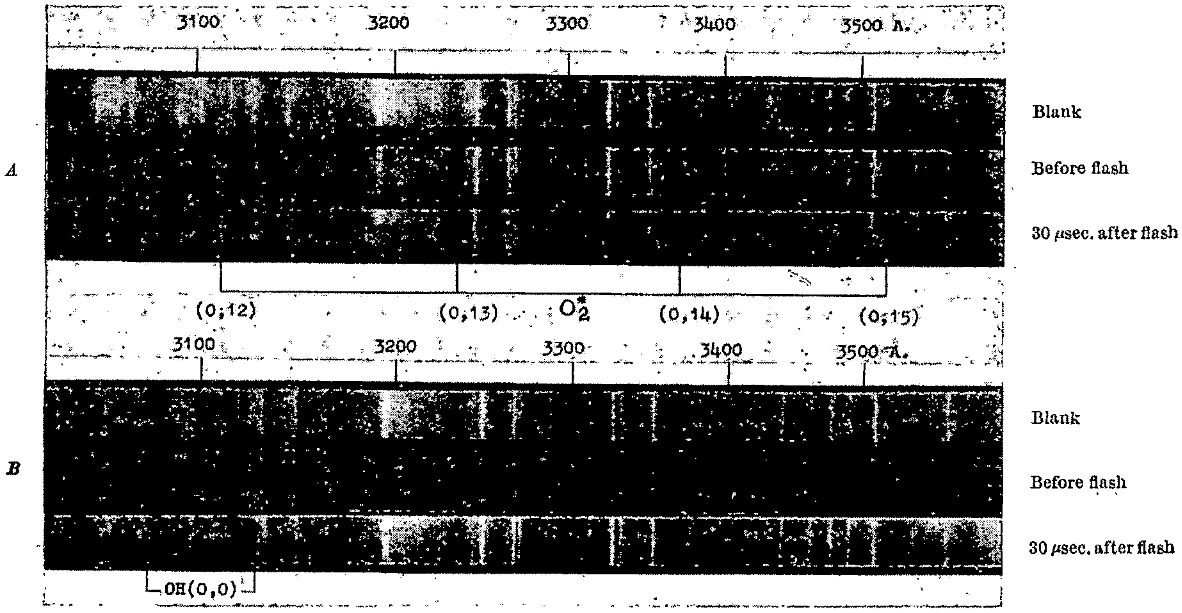

Fig. 1. Flash photolysis of ozone. *A*, dry ozone; mixture ratio ozone/nitrogen 1/100; ozone pressure 5 mm. mercury; *B*, wet ozone, mixture ratio ozone/water/nitrogen 1/3/100; ozone pressure 5 mm. mercury. Flash energy, 1,620 J.

by the flash. Repeated experiments with various mixture ratios and different partial pressures of ozone failed to detect any absorption with higher values of v''.

By introducing varying amounts of water vapour into the ozone/nitrogen mixtures we have been able to show that the effect of water on the photolysis can be attributed to the participation of OH radicals. With a mixture of ratio ozone/water/nitrogen (1/3/100) and a partial pressure of ozone of 5 mm. mercury, absorption due to OH can be detected at the shortest time attainable after flashing. The absorption is strongest at this time and decays relatively slowly. At the same time, production of vibrationally excited oxygen molecules is suppressed.

Production of OH radicals in these experiments must be brought about by reaction (3). For $O(^3P)$ this reaction is 16·8 kcal./mole endothermic, whereas for $O(^1D)$ it is 29·2 kcal./mole exothermic. It would seem certain, therefore, that under the conditions used in our experiments a considerable concentration of $O(^1D)$ atoms is produced, and that they must react preferentially with water to the exclusion of the reaction with ozone which forms the vibrationally excited oxygen in dry ozone. These facts are strikingly apparent in Fig. 1, in which corresponding mixtures of ozone and nitrogen are flashed under wet and dry conditions. Series *A* using dry ozone shows strong Schumann–Runge absorption; series *B*, with 15 mm. mercury of water vapour added, shows strong OH absorption and none due to O_2^*. In the figure only the (0,0) head of OH is shown. In agreement with this, Kistiakowsky[2] showed that decomposition in red light, which must involve ^3P oxygen atoms, is unaffected by water vapour.

These experiments indicate that the water molecules are very effective at mopping up $O(^1D)$ atoms and that it is this species which is responsible for the production of O_2^* during the photolysis of dry ozone. Subsequent reactions of the OH radical can now be written down to account for the high quantum yields previously observed as follows:

$$OH + O_3 \rightarrow HO_2 + O_2 + 42 \text{ kcal./mole} \quad (6)$$

$$HO_2 + O_3 \rightarrow OH + 2O_2 + 27 \text{ kcal./mole} \quad (7)$$

together with the possible chain-terminating reactions

$$2HO_2 \rightarrow H_2 + 2O_2 \text{ neutral} \quad (8)$$

$$2OH \rightarrow H_2 + O_2 + 12 \text{ kcal./mole} \quad (9)$$

$$2OH \rightarrow H_2O_2 + 46 \text{ kcal./mole} \quad (10)$$

$$2HO_2 \rightarrow H_2O_2 + O_2 + 31 \text{ kcal./mole} \quad (11)$$

This scheme, together with reactions (1), (2) and (3), leads to the following approximate formulæ for the quantum yield in wet ozone. In deriving the equation, k_6 and k_7 have been taken as equal and only one termination reaction is postulated.

$$\varphi = [O_3]\sqrt{\frac{K[H_2O]}{(k'[O_2][M] + k''[H_2O]I_{\text{abs.}})}} \quad (12)$$

For the case when a large amount of oxygen is present, which was so in the work of Heidt and Forbes, this approximates to:

$$\varphi = [O_3]\sqrt{\frac{K[H_2O]}{K'[O_2][M]I_{\text{abs.}}}} \quad (13)$$

If the light absorption is weak $I_{\text{abs.}} = kI_0[O_3]$ and

$$\varphi = \sqrt{\frac{K[O_3][H_2O]}{K''[O_2][M]I_0}} \quad (14)$$

These equations give the observed experimental facts such as the square root dependence of φ on the concentration of water.

Obviously from such a scheme high quantum yields are possible even when small amounts of water vapour are present, since the activation energies of (6) and (7) are not likely to be high.

The reason why $O(^3P)$ cannot propagate chains as readily at $O(^1D)$ in the photolysis of dry ozone is not entirely clear. Reaction (4) with $O(^3P)$ is 93 kcal./mole exothermic, and we have pointed out[7] that such a reaction could produce an oxygen molecule with a non-equilibrium value of vibrational energy well in excess of that required to dissociate ozone to ground-state molecules and atoms according to (15):

$$O_2^*(^3\Sigma g^-) + O_3(^1A) \rightarrow 2O_2(^3\Sigma g^-) + O(^3P) \quad (15)$$

The reaction requires 24 kcal./mole, which could be furnished by only 26 per cent of the total energy liberated in reaction (4). It may be concluded that $O(^3P)$ does not readily generate oxygen molecules with sufficient excitation for chain propagation.

For the production of $O(^1D)$ the primary step in the photolysis by ultra-violet light must be either:

$$O_3(^1A) \xrightarrow{h\nu} O_2(^1\Delta g) + O(^1D) - 91 \text{ kcal./mole} \quad (16)$$

$$\text{or } O_3(^1A) \xrightarrow{h\nu} O_2(^1\Sigma g^+) + O(^1D) - 106 \text{ kcal./mole} \quad (17)$$

Reaction (16) requires light of wave-length < 3100 A. and (17) wave-length < 2680 A. Subsequent reactions of the $O(^1D)$ according to (18):

$$O(^1D) + O_3(^1A) \rightarrow O_2^*(^3\Sigma g^-) + O_2(^3\Sigma g^-) \quad (18)$$

yield 138 kcal./mole, and it has been shown in our previous paper[7] that a high proportion of this energy appears as vibrational excitation of one of the oxygen molecules produced. Considerations of spin conservation rule out the production of excited singlet states in this reaction such as $O_2(^1\Delta g)$ or $O_2(^1\Sigma g^+)$.

Now in order for the chain to be propagated in dry ozone, the O_2^* produced in reaction (4) must in turn produce another $O(^1D)$ by reaction with ozone, according to:

$$O_2^*(^3\Sigma g^-) + O^3(^1A) \rightarrow 2O_2(^3\Sigma g^-) + O(^1D) \quad (19)$$

This requires 70 kcal./mole and hence only those O_2^* molecules with vibrational energy in excess of this will be effective. It is very significant that the highest value of v'' observed in the flash photolysis of ozone is 17, which corresponds to an energy of 66·7 kcal./mole—just too small to bring about reaction (19)—but the following value of v'', that is, 18, corresponding to 70 kcal./mole, is missing. It can be reasonably concluded that all such molecules with 18 or more quanta react by (19) so rapidly that no appreciable concentration builds up to enable their detection by spectroscopic means.

The argument outlined here explains adequately all the features of the photolysis of both wet and dry ozone with light of various wave-lengths. It seems certain that the chain mechanism in both cases is ultimately due to the presence of the $O(^1D)$ atom, which, because of its high energy and ability to react according to (4) without any activation energy, can either produce O_2^* molecules with sufficient energy to propagate a chain reaction, or when water vapour is present to react according to (3) and yield OH radicals from which a radical-propagated chain is derived.

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ENDOGENOUS METABOLISM IN BRAIN CORTEX SLICES

By Dr. R. VRBA and JAROSLAVA FOLBERGR
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IT is known that brain cortex slices take up a considerable amount of oxygen when incubated without added substrate[1,2]. The consumption of lactic acid and carbohydrate contained in brain slices accounts for only a fraction of the observed total uptake of oxygen[2]. It is well known that ammonia formation is considerably increased when nervous tissue, and especially brain cortex slices, are incubated *in vitro* without added substrate[1–9]. It seems probable, therefore, that the endogenous metabolism of brain slices is connected with ammonia formation[3].

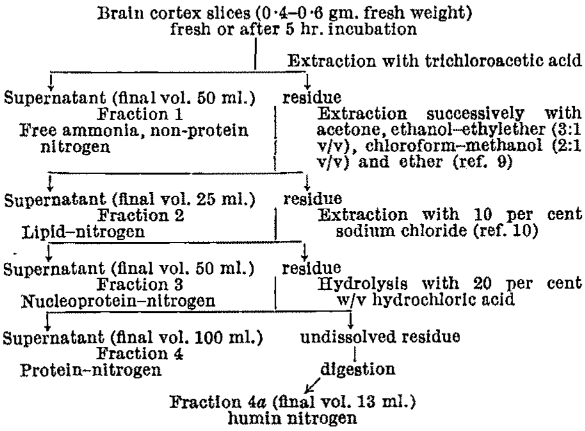
We have observed that ammonia formation in brain slices is accompanied not only by an increase of non-protein nitrogen, but also by a marked increase of lipid-nitrogen, that is, nitrogen-containing substances are transferred from the protein fraction to the lipid fraction[6,9]. It is suggested that all three processes, namely, the increase of ammonia, of non-protein nitrogen and of lipid nitrogen, may have a common root. The present experiments were an attempt to find this common source of nitrogen in brain slices, by using a simple fractionation of nitrogenous compounds in fresh and incubated slices to account quantitatively for all transfers of nitrogen.

In these experiments, only large batches of slices were used for analysis (400–600 mgm. wet weight). This diminishes the effect of individual variation between slices. All results are expressed as percentages of the total nitrogen of the slices instead of the wet weight, because despite the usual precautions it is difficult to remove the adhering liquid in a way that can be reproduced.

Each experiment was performed with twelve Warburg vessels, each containing 4 ml. of Krebs–Ringer phosphate saline without added substrate. To six vessels (non-incubated controls) 1 ml. of 50 per cent w/v trichloroacetic acid was added before the slices were introduced. Freshly cut guinea pig brain cortex slices (60–100 mgm. wet weight) were introduced into all vessels, and the six vessels not containing trichloroacetic acid were incubated in a Warburg apparatus for 5 hr. in oxygen, with shaking, at 37° C. After the incubation the vessels were detached from the manometers, and after the addition of 1 ml. of 50 per cent w/v trichloroacetic acid to each incubated vessel, the contents of these were combined. The contents of the unincubated vessels were similarly treated. Thus, two large samples of fresh and of incubated slices were obtained. Trichloroacetic acid extracts were prepared as described in more detail elsewhere[9]. The final volume of the extract was 50 ml. The rest of the tissue was then fractionated into various main groups of nitrogenous compounds according to scheme 1.

Aliquots of all four fractions were digested; free ammonia was estimated[1] in fraction 1. The digests were distilled in a Markham apparatus[12] and ammonia estimated by nesslerization.

Scheme 1. FRACTIONATION OF SLICES INTO GROUPS OF NITROGENOUS COMPOUNDS


Brain cortex slices (0·4–0·6 gm. fresh weight)
fresh or after 5 hr. incubation
Extraction with trichloroacetic acid
Supernatant (final vol. 50 ml.)
Fraction 1
Free ammonia, non-protein nitrogen
residue
Extraction successively with acetone, ethanol–ethylether (3:1 v/v), chloroform–methanol (2:1 v/v) and ether (ref. 9)
Supernatant (final vol. 25 ml.)
Fraction 2
Lipid–nitrogen
residue
Extraction with 10 per cent sodium chloride (ref. 10)
Supernatant (final vol. 50 ml.)
Fraction 3
Nucleoprotein–nitrogen
residue
Hydrolysis with 20 per cent w/v hydrochloric acid
Supernatant (final vol. 100 ml.)
Fraction 4
Protein–nitrogen
undissolved residue
digestion
Fraction 4*a* (final vol. 13 ml.)
humin nitrogen

Results of five experiments are recorded in Table 1. It may be seen that during incubation an increase of ammonia nitrogen, of non-protein nitrogen and of lipid nitrogen occurs; this increase is quantitatively accounted for by the decrease of the nitrogen in the protein and nucleoprotein fraction.

The density of the sodium chloride extract was measured in the ultra-violet, using the Soviet spectrophotometer *SF*-4, and absorption curves constructed. The measured densities were referred to 10 mgm. of total nitrogen in slices (Fig. 1). It may be seen that extracts of incubated slices show lower absorption, confirming the results in Table 1, namely, that during incubation of slices a degradation of the nucleic acids occurs. Evaluation of the results of four experiments performed are recorded in Table 2.

The fact that nucleic acids are metabolized during incubation of brain cortex slices raises the problem of the fate of the pentose in these compounds. The Mejbaums orcinol reagent was added to aliquots of the sodium chloride extract and pentoses were estimated colorimetrically[11]. As bound pentoses give a different density from free pentoses with this method, no standards were used, but the densities of extracts of fresh slices, after correction to the standard weight of 10 mgm. of total nitrogen in slices, were compared with similarly recalculated densities of the sodium chloride extracts of the incubated slices. A significant decrease of pentoses in this fraction occurs (Table 2). The deficit of pentoses in the nucleoprotein fraction cannot be accounted for by an increase of pentose in the fraction soluble in trichloroacetic acid, for an even more marked decrease of pentoses was found in this fraction by the same procedure (Table 2).

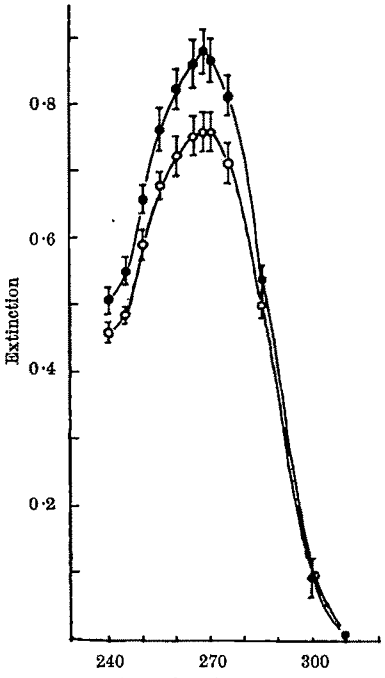


Fig. 1. Ultra-violet absorption curve of the sodium chloride extract of four experiments: ●—●, before; ○—○, after 5 hr. incubation at 37° C. with oxygen

Table 1. NITROGEN CHANGES IN GUINEA PIG BRAIN CORTEX SLICES AFTER 5-HR. INCUBATION IN KREBS–RINGER PHOSPHATE SALINE WITHOUT ADDED SUBSTRATE

Fraction	Initial	Final	Average difference	Balance
Free ammonia (ref. 1)	0·55 ± 0·08	2·73 ± 0·13	+ 2·18	+ 8·64
Non-protein nitrogen (not including free ammonia)	7·14 ± 0·54	11·14 ± 0·24	+ 4·00	
Lipid nitrogen	5·27 ± 0·57	7·73 ± 0·45	+ 2·46	
Nucleoprotein nitrogen	21·77 ± 1·49	17·65 ± 0·31	– 4·12	– 8·63
Protein nitrogen	61·87 ± 1·59	57·92 ± 0·62	– 3·95	
Humin nitrogen	3·39 ± 0·09	2·83 ± 0·17	– 0·56	

Results are expressed as percentages of total nitrogen. The means and standard errors of five experiments are given. All differences are significant ($P < 0·01$)

Table 2. PENTOSES AND NUCLEIC ACIDS AFTER 5 HR. INCUBATION OF BRAIN CORTEX SLICES IN KREBS–RINGER PHOSPHATE SALINE WITHOUT ADDED SUBSTRATE

1 Pentoses in Fraction 1 (trichloroacetic acid extract)	2 Pentoses in Fraction 3 (sodium chloride extract)	3 Nucleic acids in Fraction 3 (optical density of the extract at 268 mμ)
62·3 ± 2·7	82·8 ± 6·9	86·9 ± 5·7

Results are expressed as percentages of initial values. The means and standard errors of four experiments are given

Only small, constant amounts of orcinol-positive substances were found in acid hydrolysates of evaporated aliquots of the lipid fraction, as in the protein fraction. The conclusion to be drawn from these experiments is that degradation processes in the protein and nucleoprotein fraction, occurring during incubation of brain cortex slices, account for the accumulation of ammonia, of non-protein nitrogen and of lipid nitrogen, and are accompanied by utilization of endogenous bound pentose.

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OBSERVABILITY OF SPONTANEOUS TEMPERATURE FLUCTUATIONS

By T. P. GILL

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A NUMBER of authors, for example, Milatz and van der Velden[1], Daunt[2] and Chasmar *et al.*[3], have discussed the fundamental limits to the sensitivity of bolometers and other thermal radiation detectors. The two natural limits are Johnson noise and spontaneous temperature fluctuations in the case of the bolometer element. The following brief discussion illustrates the way in which these fluctuations may be treated.

The most important symbols used are :

$\overline{\Delta V_\theta^2}$, mean square thermal noise voltage ;
$\overline{\Delta V_J^2}$, mean square Johnson noise voltage ;
k, the Boltzmann constant (watt deg.$^{-1}$) ;
T, absolute temperature of bolometer strip (deg. K.) ;
T_0, absolute temperature of environment (deg. K.) ;
r, electrical resistance of bolometer strip (ohm) ;
Δf, narrow frequency band-width in which observations of noise are made ;
i, measuring current in bolometer (amp.) ;
β, temperature coefficient of resistance of bolometer strip, defined in this case as $(1/r)(\mathrm{d}r/\mathrm{d}T)$;
R, real part of thermal impedance of bolometer strip to surroundings at frequency f cycles/sec. ;
A, total area of bolometer (cm.^{2}) ;
σ, Stefan–Boltzmann constant (watt cm.$^{-2}$ deg.$^{-4}$) ;
η, bolometer emissivity.

The fluctuating voltage across the bolometer terminals, which ultimately defines the minimum detectable power, is usually derived from the following relations :

$$\overline{\Delta V_J^2} = 4kTr\Delta f \qquad (1)$$

$$\overline{\Delta V_\theta^2} = i^2r^2\beta^2 \,.\, 4kT^2R\Delta f \qquad (2)$$

for Johnson noise and temperature fluctuations, respectively.

The total mean square noise voltage is thus found to be :

$$\overline{\Delta V^2_{\mathrm{Tot.}}} = 4kTr\Delta f\,(1 + i^2r\beta^2TR)$$

In discussing the minimum detectable power of bolometers the next step is to introduce a formula for the sensitivity in volts per watt. However, it is proposed here to consider only the noise voltage appearing at the bolometer terminals. For sufficiently low frequencies, R can be taken as $(4\eta A\sigma T^3)^{-1}$ when the bolometer is operated *in vacuo*, and i^2r may be written as $\eta A\sigma(T^4 - T_0^4)$.

Thus,

$$\overline{\Delta V^2_{\mathrm{Tot.}}} = \overline{\Delta V_J^2}\{1 + \tfrac{1}{4}(1 - T_0^4/T^4)\beta^2T^2\} \qquad (3)$$

For a metal bolometer, βT is in the neighbourhood of unity, and since T_0 must be less than T we have :

$$\overline{\Delta V_J^2} < \overline{\Delta V^2_{\mathrm{Tot.}}} < 5/4\,\overline{\Delta V_J^2}$$

Unless β can be increased by about an order, $\overline{\Delta V_\theta^2}$ will usually be small compared with $\overline{\Delta V_J^2}$. Unfortunately, materials which have a large β usually show current noise which masks $\overline{\Delta V_J^2}$ as well as $\overline{\Delta V_\theta^2}$. The matter is made worse by the fact that the frequency spectrum of the current noise resembles that of $\overline{\Delta V_\theta^2}$ and both vary in a similar way with i. Valve noise in amplifiers also increases at low frequencies in a somewhat similar manner.

We may, however, question whether this procedure of adding $\overline{\Delta V_\theta^2}$ and $\overline{\Delta V_J^2}$ is in fact valid, since both types of fluctuation are manifestations of the same underlying phenomenon. If we cannot add these fluctuations, then the bolometer will be limited ultimately by Johnson noise, which implies that the presence and magnitude of spontaneous temperature fluctuations in bolometers should really be unobservable.

In general, it is quite wrong to expect to be able to derive fluctuations in various properties of a body from temperature fluctuations occurring spontaneously, using the normal temperature coefficient. For example, in a gas the random variations in pressure, density and temperature are not connected by the ordinary macroscopic gas laws—each of them is a different aspect of the statistical fluctuations in molecular position, velocity, etc., and they are not causally related in the sense that one can be regarded as giving rise to another. The concept of temperature itself requires careful examination in the microscopic case, since we find that heat flow is no longer simply related to temperature gradient. There are certain types of temperature-measuring devices, namely, those in which no power is supplied from outside, for which it can be shown that these spontaneous temperature fluctuations are inherently unobservable. This may be illustrated by two examples.

In the first, let us consider a very sensitive and delicate bimetallic strip which is used as a thermometer, the movement of its one free end being taken to indicate the temperature. It will undergo spontaneous fluctuations in temperature given by the well-known relation $\overline{\Delta T^2} = kT^2/c$, where $\overline{\Delta T^2}$ is the mean square temperature change and c is the thermal capacity of the body. If a temperature change of 1° C. produces a displacement S of the strip we might expect to observe a resulting fluctuation $\overline{\Delta x^2} = S^2kT^2/c$.

However, the strip must also execute Brownian motion, which is given by the relation $kT/2 = g\overline{\Delta x^2}/2$ (g being the stiffness of the strip) leading to $\overline{\Delta x^2} = kT/g$. It is clearly inadmissible to add these two fluctuations, since if we did so we would have a body with a mean kinetic energy (for this particular degree of freedom) in excess of the equipartition value.

For the second example we may consider a galvanometer, to the terminals of which a sensitive thermocouple is connected. Because of the equipartition law, the mean kinetic energy of the galvanometer suspension will be unaffected by any temperature fluctuations which may occur in the thermocouple, or for that matter by the presence or absence of the thermocouple, nor would the fluctuations exhibited by means of a valve amplifier exceed the normal Johnson noise (plus, of course, valve noise), provided always that the whole system is at the same temperature. This point is discussed in some detail by McCombie[4] and Jones and McCombie[5].

In considering the case of a galvanometer, Astbury[6] adds the fluctuations due to Johnson noise to the normal Brownian movement of the suspension. Even without the more sophisticated approach of Jones and McCombie it seems wrong to do this because of the resulting deviation from equipartition which could, in principle at least, lead to the establishing of a temperature gradient in a spontaneous manner. A somewhat similar operation to Astbury's is implied in a paper by Strong[7] and one dealing with thermopiles by Hornig and O'Keefe[8].

Referring to the bolometer, McCombie[4] says that, "unlike the thermocouple, [it] is not an equilibrium system. The strip, of which the change in temperature is to be measured, carries a steady current in order to convert changes in resistance into changes in voltage. There is, therefore, no reason to expect that the fluctuations can be discussed in terms of Nyquist's result". From this it is clear that to use arguments based on equilibrium conditions is unsound. Now the Nyquist–Johnson formula, equation (1), is, of course, based on equilibrium conditions but still is found to hold for metallic conductors even when they are carrying current. Equation (2) also may be derived from a consideration of equilibrium conditions (see ref. 2). It is, in fact, quite common to treat the bolometer as an equilibrium system, although this cannot be justified except by the correctness of the results obtained. In other words, if we are justified in treating the bolometer as an equilibrium system, it is not clear that we should expect to be able to observe spontaneous temperature fluctuations. If we are not so justified, our conclusions will be open to question in any event. It therefore seems desirable that the question should be examined experimentally.

I have carried out[9] a number of experiments with evaporated-gold bolometers as small as 0·2 mm. square, but in no case has a condition been achieved where the spontaneous fluctuations in temperature might be observed. The reason for this was mainly the fact that the gold in the thin film used had a temperature coefficient of resistance of the order of one-third of that of the bulk metal, which reduced βT to about 1/3 and would therefore have required the root-mean-square noise to be measured to much better than 5 per cent, which was beyond the capabilities of the equipment used. Current noise was also present in most cases, and even where it was small compared with Johnson noise could still mask any temperature fluctuations. Other considerations have prevented the subject being pursued, but it seems possible that the problem might be attacked using thin platinum strips, similar to those used by Chasmar and others[3].

It will be noticed that the thermal capacity of the bolometer does not enter into equation (3); but this does not mean that we can therefore use robust resistance thermometers. The apparent paradox is produced by our limiting ourselves to 'sufficiently' low frequencies, and a more complete analysis shows that in practice a very delicate device indeed must be used if we can realize the figure given by equation (3).

The arguments above are by their nature not rigorous, but nevertheless it is felt that a case has been established for reviewing the assumption that spontaneous temperature fluctuations are observable, as such, particularly in the case of the bolometer.

I wish to acknowledge my indebtedness to Dr. F. W. Woltersdorf, formerly of the Department of Supply, Commonwealth of Australia, for many fruitful discussions on the subject of this communication and allied topics, and to thank the Chief Scientist, Department of Supply, for permission to publish it.

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LIVER GLUCOSYL OLIGOSACCHARIDES AND GLYCOGEN; EFFECTS OF STARVATION, GLUCOSE FEEDING AND INSULIN

By DR. HSIEN-GIEH SIE and PROF. W. H. FISHMAN

Tufts University School of Medicine and the New England Center Hospital, Boston, Mass.

RECENTLY, we have succeeded in isolating and identifying rat liver maltose, maltotriose and maltotetraose, and in recognizing higher members of an ascending homologous series of glucosyl oligosaccharides[1]. These were findings made unexpectedly during an investigation of the nature of glucosiduronic acids in liver.

The purpose of the present article is to present other results which justify the giving of more than passing attention to the question of the significance of these hepatic glucosyl oligosaccharides.

Male albino rats (250 gm.) were fasted for different lengths of time up to 24 hr. and then killed. The liver was removed and two 1-gm. portions of it were frozen (deep freeze) and analysed later for glycogen by Roe's method[2] and for glucosyl oligosaccharides by the method described in the following paragraph.

A 1-gm. specimen of liver was homogenized in 10 ml. of cold distilled water and was immediately deproteinized with 1 ml. 10 per cent zinc sulphate solution and 1 ml. 0·5 *N* sodium hydroxide solution. After centrifugation, the supernatant was collected, and washings of the precipitate (3 portions of 10 ml. cold water) were added to it. Supernatant and washings were pooled and treated with 3·0 gm. activated charcoal for 5 min. at room temperature. The charcoal was collected on a Buchner funnel and washed repeatedly with 20-ml. portions of water (total volume 250–500 ml.). The oligosaccharides were eluted from the charcoal with 3 × 20 ml.

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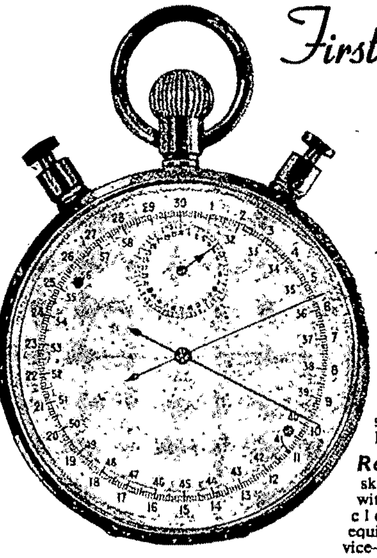

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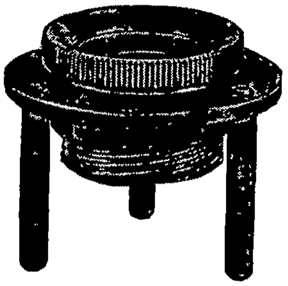

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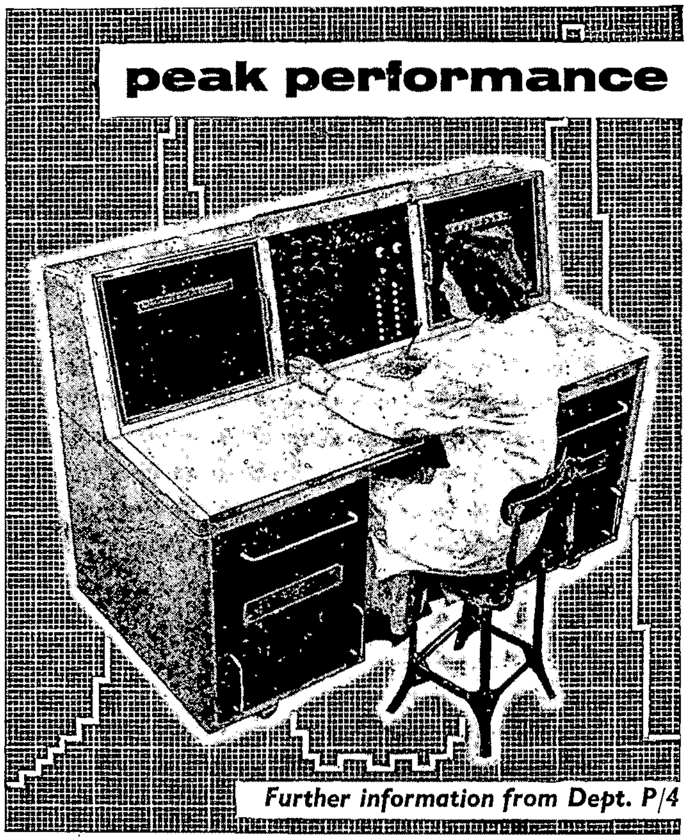

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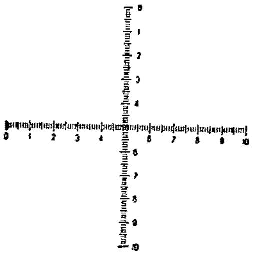

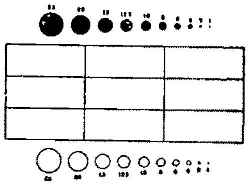

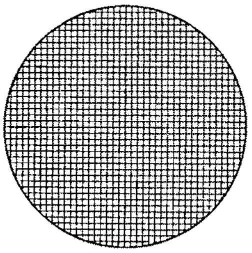

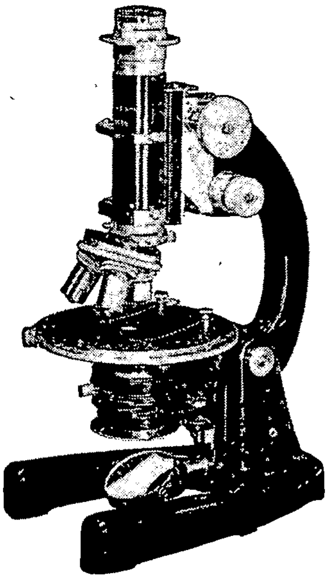

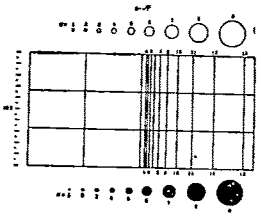

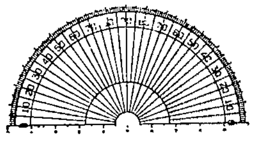

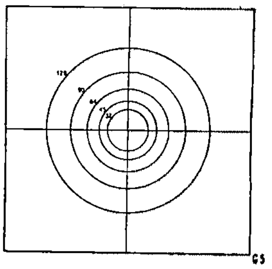

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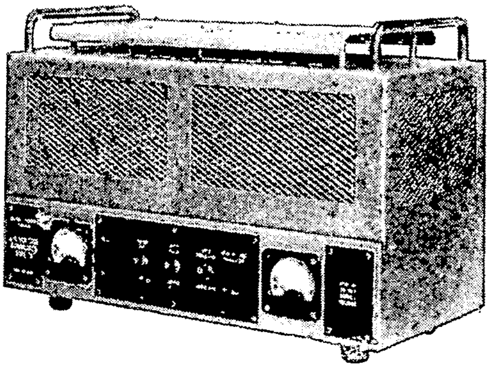

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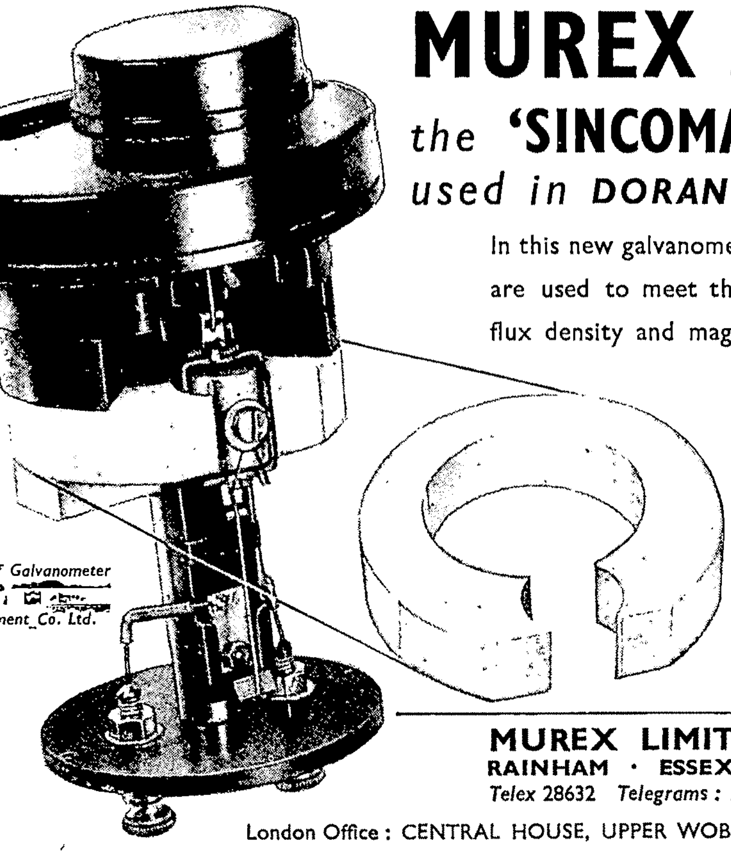

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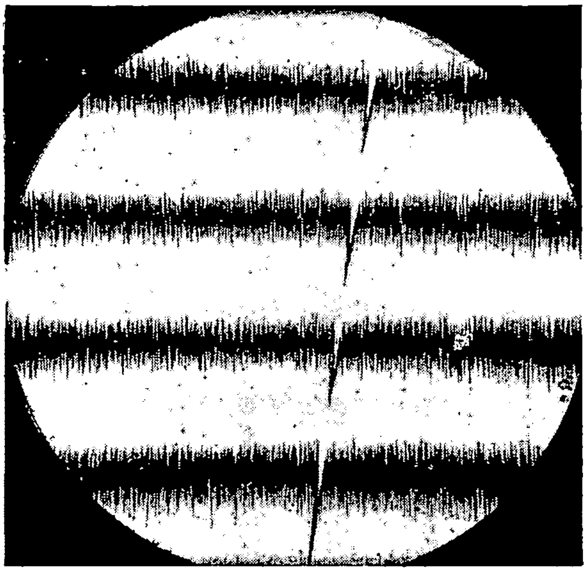

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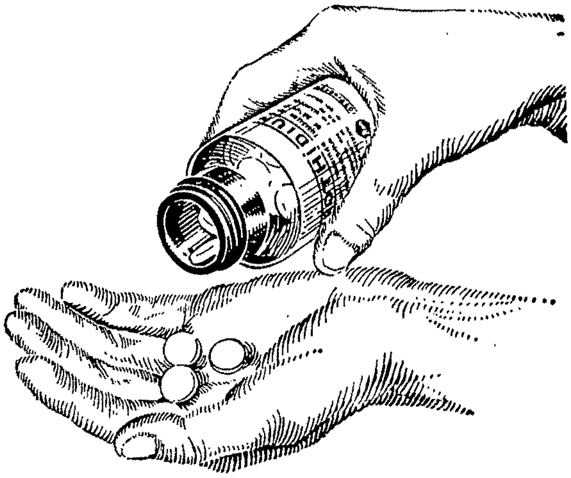

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portions of hot ethyl alcohol (95 per cent). Then the charcoal was transferred to a beaker and extracted with 2 × 20 ml. of hot ethanol, which was decanted and filtered finally through the original Buchner. An aliquot (0·2–1·0 ml.) of the alcoholic eluate was analysed by the Dische reaction[3]. The recovery of pure maltose when treated as above was 97 per cent and as little as 2–5γ of it can be measured. The results are expressed as mgm. of oligosaccharides per 100 gm. of liver in terms of the number of glucosyl residues. The results are shown in Fig. 1.

After 24-hr. starvation, glucose (2·0 gm. in 3·5 ml.) was administered by stomach tube. Of these animals, 6 received a second dose of 2·0 gm. of glucose 28 hr. after time zero. At the time-intervals indicated in Fig. 1, the animals were killed and their liver oligosaccharides and glycogen determined as described above.

It was observed that on starvation, rat-liver glycogen underwent a progressive and regular decline to disappearance-levels after 8 hr. In the case of the glucosyl oligosaccharides, a parallel decrease was observed but not to the same extreme degree as was noted for glycogen. In this regard, it may be reasoned that if the oligosaccharides were derived solely from glycogen breakdown, then coincident with the profound drop in liver glycogen one should expect to find a noticeable increment in liver oligosaccharides. This event did not occur.

The administration of glucose to starved rats caused a rapid restoration of liver glycogen to the pre-starved level, as expected. The amount of liver oligosaccharides increased also but at a slower rate than was the case for glycogen.

Liver glycogen and glucosyl oligosaccharides were determined 2 hr. after 6 rats received 4 units each of insulin (Lilly) subcutaneously (Fig. 2).

Insulin administration resulted in a characteristic marked decrease in hepatic glycogen[4]. This was accompanied by a parallel diminution in glucosyl oligosaccharides (Fig. 2). Qualitatively, similar results were obtained in rats starved for 24 hr. and then given glucose and insulin.

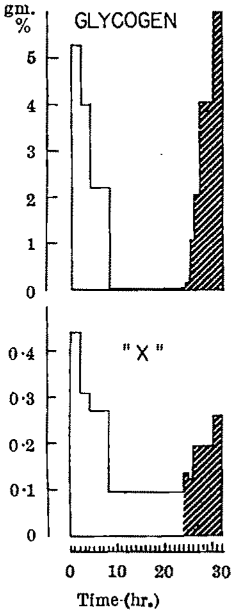

Fig. 1. Liver glycogen and glucosyl oligosaccharides ("X") in relation to hours of starvation and to subsequent glucose administration (shaded areas). The numbers of rats employed for each time-interval (hr.) were, respectively: 0–2, 11; 2–4, 4; 4–8, 5; 16–24, 10; 24–25, 6; 26–27, 6; 27–30, 6; 30–32, 8

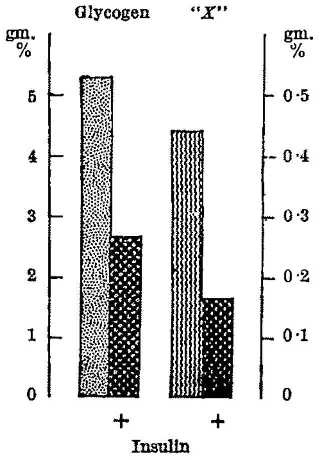

Fig. 2. Effect on liver glycogen and glucosyl oligosaccharides of subcutaneously injected insulin. Six rats maintained on an *ad libitum* diet were killed as controls for six other rats which were killed 2 hr. after receiving the insulin

Thus, in three different sets of physiological circumstances (starvation, glucose feeding, insulin administration), hepatic glucosyl oligosaccharides fluctuated in the same direction as did liver glycogen.

The possibility of artefacts due to the isolation is unlikely inasmuch as the glucosyl oligosaccharides can be separated from liver by simple physical means (centrifugation, dialysis) and since no oligosaccharides result from glycogen which has been subjected to the isolation process[1].

The possibility was also considered that oligosaccharides were produced from glycogen by amylase in blood contaminating the liver homogenate. The duration of this action would be the interval separating removal of the liver to the deproteinization of the homogenate.

In this connexion, it was first shown that rat-liver supernatant does not produce detectable amounts of oligosaccharides from glycogen or starch in the time interval referred to above. Thus, 2 gm. of fresh rat liver were homogenized in 15 ml. of ice-cold distilled water and centrifuged at high speed in a refrigerated centrifuge for 30 min. The supernatant was tested for amylase activity using two substrates, starch and glycogen. The soluble starch (1 per cent) was made up in phosphate buffer *p*H 6·9 according to Bernfeld[5] and the glycogen (1 per cent) in 0·02 *M tris* buffer (*p*H 7·4) and 0·0067 *M* sodium chloride. The experimental digests contained 1 ml. of buffered substrate and 1 ml. of liver supernatant solution. The controls contained boiled supernatant. The digests were incubated at 20° C. for 3 min. and the reaction stopped by boiling. The addition of 0·5 ml. of 10 per cent zinc sulphate and 0·5 ml. 0·5 *N* sodium hydroxide precipitated the protein, which was filtered off. The reducing power of the filtrate was determined[6]. No increase in reducing power of the test digests versus controls was observed, signifying the absence of amylase activity under the conditions employed.

Moreover, experiments were done in which the portal vein of the liver of a nembutalized rat was perfused *in situ* with Ringer's solution to remove as much as possible of the blood trapped in the tissue. Subsequent analysis showed the presence of glucosyl oligosaccharides in amounts similar to those usually found in the unperfused liver.

Finally, it may be expected that if glycogen was undergoing amylolytic degradation in the liver homogenate then the extent of this process should progressively increase with time. This expectation was not realized. Thus, a 10 per cent rat-liver homogenate was prepared and kept at 0° C. At five different time-intervals up to 15 min., aliquots were removed and the glucosyl oligosaccharides were determined. The concentration of this material (125 mgm. per cent) was unchanged during the course of this experiment.

On the other hand, the evidence does not rule out the possibility that in the intact animal, glucosyl oligosaccharides may result from the physiological action of liver amylase. If this is the case, the extent of this process is much greater than expected and its control by the physiological influences examined here would represent facts, unemphasized hitherto if they were known at all.

It is regarded as significant that the liver contains an amylomaltase[7] which synthesizes maltotriose and maltotetraose from maltose. The role of this series of compounds is understood in the carbohydrate metabolism of plants. They function as primers in the synthesis of polysaccharide catalysed by plant phosphorylase[8–12]. On the other hand, glucosyl oligosaccharides may be intermediates in glycogen synthesis if one considers the case where a trisaccharide (not a substrate) speeded up dextran synthesis catalysed by cell-free extracts of *Aspergillus niger* by serving as a glucosyl acceptor[13].

The implication of the above findings is that glucosyl oligosaccharides (no matter what their origin) may enter somewhere into the mechanism of glycogen synthesis. In this connexion, it is of interest that Beloff-Chain[14] has observed the presence of maltose, maltotriose and maltotetraose in rat diaphragm exposed to glucose labelled with carbon-14. Synthesis of oligosaccharides and glycogen from glucose but not glucose-1-phosphate was stimulated by insulin. Certainly the findings of Beloff-Chain on rat diaphragm resemble the present observations in rat liver.

We are satisfied from the results presented that the presence of glucosyl oligosaccharides in liver homogenate is not due to artefact. The exclusion of this explanation brings us face to face with the questions of their origin and of their possible significance in the metabolism of liver glycogen. These are deserving of further experimental study.

This work was supported in part by grants-in-aid (*MET*-44) from the American Cancer Society, Inc., New York, and (656-*Cl*) from the Massachusetts Division of the American Cancer Society, Boston, Mass.

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INHIBITION AND ACTIVATION OF POLYNUCLEOTIDE PHOSPHORYLASE THROUGH THE FORMATION OF COMPLEXES BETWEEN ACRIDINE ORANGE AND POLYNUCLEOTIDES

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ACRIDINE orange reacts with the bases of polyadenylic acid to form a spectrophotometrically distinct complex (complex I) with an absorption peak at 465 mμ [1] (see Fig. 1). We have also discovered, however, that with an excess concentration of polymer (ratio of bases to dye 100 : 1) complex I disappears and is replaced by a second complex, II, with an absorption peak at 502 mμ associated with strong fluorescence in the green (Table 1). Treatment of polyadenylic acid with formalin, which blocks the formation of complex I [1], does not prevent the formation of complex II. The addition of magnesium reduces the concentration of complex II (see inset *B* of Fig. 1) and increases the concentration of complex I. Magnesium has no effect on the formation of complex I at nucleotide–dye mole ratios of 1 : 1 or less[1]. Low concentrations of sodium hydroxide ($3 \times 10^{-4}\,M$) abolish complex I, but do not affect complex II; high concentrations of sodium hydroxide ($3 \times 10^{-3}\,M$) abolish complex II and free the dye in its alkaline form with an absorption peak at 440 mμ. In view of the insensitivity of complex II to formalin treatment and of its sensitivity to magnesium we conclude that acridine orange can be bound by the phosphate groups of polyadenylic acid as well as by the purine bases. The affinity of the phosphate groups for the dye is considerably greater than that of the purine base. A competition exists between magnesium and acridine orange for the phosphate groups ; another competition exists between hydroxyl ions and phosphate groups for the dye, which has a *pK* of approximately 10·1.

Alkaline degradation of polyadenylic acid results in a transient increase in the amount of complex II formed with acridine orange followed by a gradual drop to zero (see inset *A* of Fig. 1). In view of the stoichiometry of the complex II reaction and the transient increase during hydrolysis, it appears likely that the dye is bound preferentially to the secondary terminal phosphates. Phosphorylysis of polyadenylic acid with polynucleotide phosphorylase shows no transient increase, but a gradual decrease in the amount of complex II formed. The former is consistent with a random splitting of the inter-nucleotide bonds ; the latter is consistent with a splitting of the terminal internucleotide bonds. These results also indicate no stereospecificity towards the 3′- or 5′-secondary phosphates.

Complexes I and II are also formed with ribonucleic acid isolated from *M. lysodeikticus*, but there is no sharp separation between the appearances of complexes I and II as the concentration of ribonucleic acid is increased. Similar observations have been made with the copolymer, polyadenylic uridylic acid. This reflects the much higher ratio of secondary phosphate groups to the adenine and cytidine bases in the low molecular weight ribonucleic acid and the low adenine content in the co-polymer.

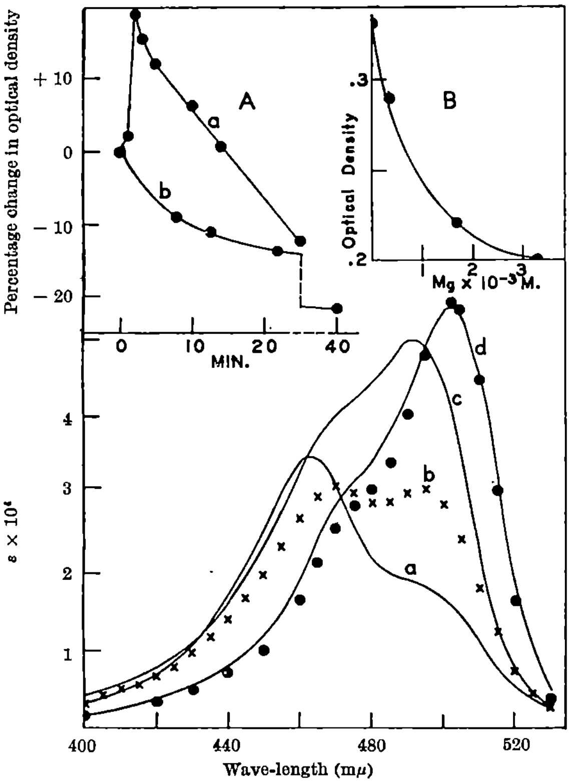

Fig. 1. Absorption curve of acridine orange (10^{-5} *M*) and its complexes at *p*H 7·0 in 0·017 *M* phosphate buffer. Curve *a*, complex I with polyadenylic acid ($1 \cdot 9 \times 10^{-5}$ *M*) ; *b*, complex I with ribonucleic acid ($7 \cdot 2 \times 10^{-5}$ *M*) ; *c*, free acridine orange ; *d*, complex II with polyadenylic acid (9×10^{-3} *M*) ; closed circles, complex II with deoxyribonucleic acid ($4 \cdot 9 \times 10^{-3}$ *M*). (Concentrations recorded as total organic phosphate.)

Inset *A* : *a*, per cent change in optical density at 500 mμ of complex II with polyadenylic acid during alkaline hydrolysis of the polymer at 100° in 3×10^{-3} *M* sodium hydroxide ; *b*, per cent change in optical density at 500 mμ of complex II with polyadenylic acid during phosphorylysis by polyase in $2 \cdot 7 \times 10^{-2}$ *M* dipotassium hydrogen phosphate, *p*H 9·0, $5 \cdot 4 \times 10^{-4}$ *M* magnesium chloride, 37°. Colour test : 0·5 ml. of polyadenylic acid solution, 0·5 ml. 0·01 *N* sodium hydroxide, 1·0 ml. water, 1 ml. $2 \cdot 91 \times 10^{-5}$ *M* acridine orange.

Inset *B* : decrease in concentration of complex II with polyadenylic acid with increasing concentrations of magnesium. Optical density recorded at 500 mμ. Reaction mixture contained 0·017 *M* phosphate buffer, *p*H 7·0, $2 \cdot 1 \times 10^{-4}$ *M* polyadenylic acid, 10^{-5} *M* acridine orange and magnesium chloride

Table 1. EFFECT OF DEOXYRIBONUCLEIC ACID (DNA) AND POLYADENYLIC ACID (POLY A) IN LARGE EXCESS UPON THE ABSORPTION SPECTRUM AND FLUORESCENCE INTENSITY OF ACRIDINE ORANGE

The solvent is 0·01 *M* sodium acetate, 0·5 *M* potassium chloride, *p*H 6·6

Dye conc. × 10^{-6} *M*	Material added	Concentration	Optical density, $\lambda = 500$ mμ	Relative fluorescence intensity, $\lambda_a = 490$ mμ $\lambda_b = 500$ mμ
3·3	none	—	0·089	1·0
3·3	poly A	$1 \cdot 41 \times 10^{-8}$ *M* (AMP units)	0·101	2·2
3·3	HCHO-poly A	$1 \cdot 41 \times 10^{-3}$ *M*	0·101	2·2
5·0	none	—	0·245	1·0
5·0	DNA	3×10^{-3} mgm./ml.	0·260	1·3
5·0	DNA	6×10^{-3} mgm./ml.	0·269	1·4
5·0	DNA	0·45 mgm./ml.	0·296	2·9

Complex II is also formed with deoxyribonucleic acid. (This excludes the 2′-hydroxyl groups of the polyribonucleotides.) The absorption spectrum of the deoxyribonucleic acid complex II is almost identical with that of polyadenylic acid. No evidence for complex I with deoxyribonucleic acid has been obtained with either native or alkaline denatured material. The green fluorescence of nuclei stained with acridine orange observed by Armstrong and Niven[2] is, no doubt, the result of the formation of complex II with deoxyribonucleic acid. The red fluorescence (phosphorescence ?) reflects the formation of a mixture of complexes I and II with ribonucleic acid. The deoxyribonucleic acid complex II is probably the same deoxyribonucleic acid-dye complex described by Peacocke and Skerrett[3] for other dyes of the acridine series. The failure of deoxyribonucleic acid to form complex I provides a potentially highly specific and sensitive method for determining deoxyribonucleic/ribonucleic acid ratios in nucleic acid mixtures. Moreover, if the nonreactivity of the 6′-amino-groups of deoxyribonucleic acid is a function of its double helical structure, then it would appear likely that ribonucleic acid is a single helix.

Alkaline hydrolysis of ribonucleic acid abolishes its ability to form complexes I and II. Boiling deoxyribonucleic acid in 0·05 *N* sodium hydroxide for 1 hr. has no effect on its ability to form complex II. Adenosine 5′-phosphate and adenosine diphosphate at concentrations of 10^{-3} *M* do not form complex II with acridine orange. The proteins, lysozyme and albumin, do not form complexes I or II. Methylene blue forms analogous complexes I and II with the respective absorption peaks at 600 and 670 mμ. Complex II is not sensitive to alkali, reflecting the fact that methylene blue does not possess a *pK* in the alkaline region.

The rate of synthesis and phosphorylysis of polyadenylic acid by polyase is inhibited by acridine orange. This can be reversed by increasing the concentration of magnesium (Table 2), even under conditions in which magnesium itself becomes progressively inhibitory. The curve of the rate of polymerization versus adenosine diphosphate concentration has a slope independent of the concentration

Table 2. EFFECT OF CONCENTRATION OF MAGNESIUM ON THE INHIBITION BY ACRIDINE ORANGE OF THE RATE OF SYNTHESIS OF POLYADENYLIC ACID

Rate recorded as moles of inorganic phosphate released × 10^{-6} in 20 min., temp. 37°, *tris* buffer, 0·017 *M*, *p*H 9·5, 6·35 × 10^{-4} *M* adenosine diphosphate, 5·8 × 10^{-5} *M* acridine orange, 0·17 *M* potassium chloride

Magnesium × 10^{-4} *M*	3·33	6·67	10·0	13·3	16·7
Control	21·6	19·7	18·0	16·7	15·5
Inhibited	14·1	13·6	13·1	12·8	12·1
Difference	7·5	6·1	4·9	3·9	3·4
Per cent inhibition	35	29	27	22	21

Table 3. EFFECT OF CONCENTRATION OF ADENOSINE DIPHOSPHATE (ADP) ON THE INHIBITION BY ACRIDINE ORANGE OF THE RATE OF SYNTHESIS OF POLYADENYLIC ACID

Experimental conditions are the same as in Table 2. 3·3 × 10^{-4} *M* magnesium chloride

ADP × 10^{-4} *M*	1·25	1·88	3·15	6·25	9·4	12·5
Control	5·27	7·5	10·6	16·4	20·4	23·3
Inhibited	2·15	3·5	7·1	12·9	16·6	19·8
Difference	3·12	4·0	3·5	3·5	4·3	3·5
Per cent inhibition	59	49	33·3	21·5	20·6	15

Table 4. EFFECT OF POLY A CONCENTRATION ON THE INHIBITION BY ACRIDINE ORANGE OF THE RATE OF PHOSPHORYLYSIS OF POLYADENYLIC ACID

Rate given in arbitrary units, temp. 37°, *p*H 8·5, 0·07 *M tris*, 0·02 *M* phosphate, 1·4 × 10^{-4} magnesium chloride, 1·25 × 10^{-4} acridine orange, 0·14 *M* potassium chloride

Poly A × 10^{-4} *M* (AMP units)	0·88	1·74	3·47	6·95	13·9*
Control	77	92	103	112	93
Inhibited	0	0	54	71	68
Difference	77	92	49	42	25
Per cent inhibition	100	100	48	37	27

* Separate experiment

Table 5. EFFECT OF POTASSIUM CHLORIDE CONCENTRATION ON THE INHIBITION BY ACRIDINE ORANGE OF THE RATE OF POLYMERIZATION OF POLYADENYLIC ACID

Experimental conditions the same as in Table 2. 3·3 × 10^{-4} *M* magnesium chloride

Potassium chloride × 10^{-2} *M*	1·67	3·3	5·0	6·67	8·35
Control	25·2	31·8	34·0	38·0	37·0
Inhibited	16·1	20·7	23·4	23·7	22·8
Difference	9·1	11·1	11·6	14·3	14·2
Per cent inhibition	36·4	35	31·3	40	38

of acridine orange. Thus a fixed drop in the polymerization-rate occurs which is independent of the substrate concentration (Table 3). Nevertheless, the per cent inhibition decreases with increasing substrate concentration. A similar relationship exists between the rate of phosphorylysis of polyadenylic acid and its concentration (Table 4). However, there are both relative and absolute decreases in inhibition by acridine orange.

These findings indicate that acridine orange inhibits by forming a complex with the polymer, presumably complex II. The constant drop in the rate of polymerization in the presence of acridine orange is consistent with the previous conclusion[4] that the rate-determining parameter in the polymerization process is the concentration of the polymer molecules, of which a fixed quantity is removed for a given concentration of acridine orange. Moreover, these results also appear to show that this enzyme system is able to synthesize additional polymer molecules, the concentration of which is proportional to the initial concentration of adenosine diphosphate. Further evidence for this has been obtained by observing an increase in the concentration of complex II formed during the polymerization process with increasing concentrations of adenosine diphosphate or enzyme and with time. At low ionic strength the inhibition by acridine orange of polymerization can be reversed by the addition of polyadenylic acid. A similar effect is observed with the contaminating ribonucleic acid of the enzyme preparations.

Under conditions in which the quantity of ribonucleic acid contamination of the reaction mixture is low and the ionic strength relatively high, varying the concentration of salt, which has been found to vary the Michaelis constant[5,6], has no effect on the per cent inhibition by the dye but does cause an absolute change in the rate of polymerization (Table 5). This indicates that ionic strength influences the polymerization reaction but does not affect the rate or extent of synthesis of primer. Other studies have shown that increasing potassium chloride concentrations strongly activate the rate of phosphorylysis of polyadenylic acid by polyase[7]. Thus far, no evidence of a disproportionation between the rate of polymerization and phosphorylysis of polyadenylic acid has been obtained with various purified fractions of the enzyme, which would suggest the presence of a primer synthesizing enzyme in addition to a polymerizing enzyme[7,8].

The above picture is complicated by the finding that at low concentrations of potassium chloride and acridine orange the dye can increase the polymerization-rate more than 100 per cent. The addition of magnesium enhances the activation by the dye. Increasing the substrate concentration decreases the relative extent of activation but does not appear to reverse it. At fixed concentrations of acridine orange increasing concentrations of ribonucleic acid in the polymerization reaction mixture cause a marked decrease in the inhibition by the dye, followed by a marked activation. These findings suggest that the activation by the dye may occur through the formation of complex I. It is possible that the activation process involves neutralization of the internucleotide phosphates by the bound dye. A similar result is obtained from the shielding effect of high concentrations of potassium chloride.

Preliminary studies of the effect of acridine orange on the growth of *M. lysodeikticus* in submerged cultures[9] at *p*H 8·5 show that the extent of inhibition of growth by a given concentration of the dye depends upon the size of the inoculum. In one experiment 10^{-7} *M* acridine orange inhibited the extent of growth of a 24-hr. culture 40 per cent. A concentration of 1·4 × 10^{-4} *M* magnesium chloride completely overcame this inhibition. It would appear, therefore, that at sublethal concentrations of the dye the mechanism of inhibition of growth is through the formation of complex II. The biological role of polyase may, therefore, be implicated.

We wish to acknowledge the technical assistance of Miss R. Shriver, Miss G. Armelie and Mr. J. Handler. This research is being supported at the Children's Hospital by U.S. Public Health Grant No. *C*-3293, National Cancer Institute, National Institutes of Health; by the Louise C. Bowles Research Fund; and by a grant from Miles Laboratories, Inc.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Preparation of Block and Graft Copolymers in Systems where the Life-time of the Kinetic Chain is Long

We have reported[1] that block copolymers may be prepared by adding methyl methacrylate to a latex of polyvinyl acetate prepared by gamma-irradiation of the monomer emulsion. Polymer radicals trapped in latex particles initiate polymerization of the second monomer, forming linear block copolymer molecules.

It is apparent, however, that more copolymer is formed than can be accounted for by this mechanism. Latexes prepared from 1 gm. of vinyl acetate containing of the order of 10^{16} latex particles should, following the arguments of Smith and Ewart[2] that half the particles contain live radicals, give a yield of block copolymer of approximately 2 mgm. In fact these latices have been found to yield 0·05–0·10 gm. of copolymer per gram of vinyl acetate together with large excesses of methyl methacrylate polymer.

During the polymerization of the second monomer no further radicals are generated, the propagating radicals remain trapped in the latex particles and so mutual termination reactions do not occur. The kinetic chain-length is thus essentially limited only by the amount of methyl methacrylate added. The molecular weight of the polymer molecules is, of course, limited by chain transfer reactions. During the course of the polymerization of a gram of methyl methacrylate by 10^{16} radicals, transfer to monomer and polymer must occur many times. Transfer to monomer will account for the pure polymethyl methacrylate found in the system. Transfer to polyvinyl acetate will lead to branched graft copolymer molecules which must form the preponderant part of the copolymer yield.

Transfer-limited molecules may also be obtained by adding styrene emulsions to previously irradiated polymethyl methacrylate films. Small amounts of block copolymer are found in the film, but the bulk of the polymerization occurs in the supernatant styrene emulsion. The characteristics are essentially similar to a true emulsion polymerization. The rate is given by $k_p n[M]$, where k_p is the propagation constant for styrene, $[M]$ the monomer concentration and n varies between the number of latex particles formed and half that number. The temperature increment of the rate is 7·2 kcal., which is close to the energy of activation of propagation for polystyrene. The molecular weight of the polystyrene is exceptionally high, measurements of viscosity indicating a range of $4–12 \times 10^6$. The samples of higher molecular weight have high Huggins constants[3] and are probably highly branched.

Our suggestion is that polymerization proceeds in the polymer film until such time as transfer to monomer occurs and the resulting small radicals escape into the supernatant phase and initiate emulsion polymerization of styrene. The size of the polystyrene formed is, to a large extent, limited only by transfer. The measured molecular weights are in fact in excess of the limit to the number average set by the monomer transfer constant, but a dead polymer molecule can resume growth as a branched molecule if another radical is transferred to it.

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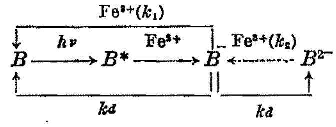
Photo-reduction of Methylene Blue and Thionine by Ferrous Sulphate using Flash Irradiation

When dilute solutions of methylene blue in 0·1 N sulphuric acid are subjected to flash photolysis with orange-red light in the presence of ferrous sulphate ($\sim$ 0·1 M), the kinetic curves obtained by monitoring at various wave-lengths can all be interpreted in terms of the following reaction scheme:



By direct measurement, the rate constant (k_d) for the dismutation of the semiquinone radical (B^-) was found to be of the order $1·5 \times 10^9$ l. mole^{-1} sec.$^{-1}$. By observing the degree to which the formation of leuco methylene blue (B^{2-}) was suppressed by the addition of ferric iron, the value of k_1/k_d and hence k_1 ($\sim 2·4 \times 10^5$ l. mole^{-1} sec.$^{-1}$) was obtained. The latter is so much smaller than k_d that the quantity of ferric iron produced by the photochemical reaction has no appreciable effect on the dismutation of the semiquinone radical.

The reverse of the dismutation reaction, if sufficiently rapid, would lead to an appreciable equilibrium concentration of semiquinone in partly reduced methylene blue solutions. This would allow of two routes for the re-oxidation of the leuco-base, namely, by direct reaction with ferric iron, or by reaction of ferric iron with the equilibrium concentration of semiquinone. Rough observations of the rate of re-oxidation, taken in conjunction with the above value for k_1, suggest that the equilibrium concentration of semiquinone must be very much less than the value reported by Michaelis and co-workers[1] for dilute acid solutions.

In view of the observations of Bridge and Porter[2,3], it is of particular interest to determine whether the semiquinone in the present experiments is produced via the triplet state or by direct reaction of the excited singlet state. This point has been investigated with thionine, the behaviour of which on flash photolysis is qualitatively similar to that of methylene blue. If the semiquinones were formed solely by reaction of the excited singlet states of the dyestuffs, the quenching of fluorescence by ferrous sulphate should be related to the yield of semiquinone by the expression:

$$\frac{\varphi_\infty}{\varphi} = 1 + \frac{1}{K[\mathrm{Fe}^{2+}]}$$

where φ_∞ refers to the yield of semiquinone in the presence of a large excess of ferrous iron, and K is the normal Stern–Volmer fluorescence quenching constant (K is of the order 1 l. mole^{-1} for thionine under the conditions of experiment). With thionine the above relationship is not obeyed. The yield of thionine semiquinone rises to 50 per cent of its maximum value within the range $[Fe^{2+}] = 10^{-3}$–10^{-2} M, where the stationary concentration of triplet is decreasing rapidly. Since 50 per cent quenching of fluorescence is only reached at $[Fe^{2+}]$ in the region of 1 M, it appears that direct reaction of the singlet excited state is very small at the lower concentrations of ferrous iron, and in the latter region therefore the semiquinone must originate from some other source, presumably the triplet state. It is possible that the semiquinone is formed from the excited singlet state also, at the high concentrations of ferrous iron required to quench fluorescence.

The work with thionine and methylene blue is being continued and will be reported in detail elsewhere.

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Spectrophotometric Determination of Protein in Alkaline Solution

This method for the spectrophotometric determination of protein in alkaline solution was developed in order to determine the protein of *Chlorella* cells. It was not possible to obtain *Chlorella*-cell protein, readily, in acid solution. It was possible to break most of the cells by grinding mechanically with silica sand but this method is tedious and time-consuming. The latter point is important when it is necessary to measure physiological changes which proceed at a rapid rate.

Total protein was measured by the Folin phenol reagent[1] with a Zeiss spectrophotometer (Type *PMQ*II). All compounds which contain peptide bonds give a colour reaction and are measured by this method, but the actual figures obtained were based on total nitrogen as determined by the Kjeldahl technique. Kjeldahl nitrogen was converted to protein by using the usual factor of 6·25 (ref. 2).

The reagents used in the spectrophotometric method were:

(*A*) 2 per cent sodium carbonate in 0·1 N sodium hydroxide.

(*B*) 0·5 per cent crystalline copper sulphate ($CuSO_4.5H_2O$) in 1 per cent sodium or potassium tartrate (which was freshly prepared because complex salts were precipitated after standing for about an hour).

(*C*) Alkaline copper solution (1 ml. of reagent *B* was mixed with 50 ml. of reagent *A*. This solution was discarded after one day).

(*D*) Folin reagent diluted with water, 1 : 1 (this is the phenol reagent of Folin and Ciocalteu, manufactured by Bayer, West Germany).

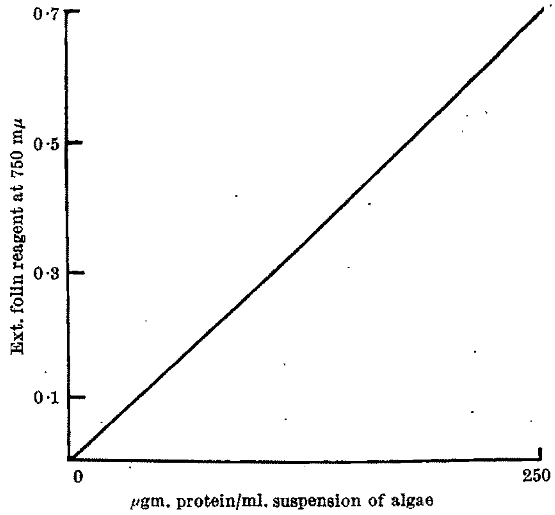

Fig. 1. Calibration curve

The experimental procedure was as follows: 5 ml. of an algal suspension was placed in a 15-ml. centrifuge. The cells were centrifuged, washed, 5 ml. of 1 N sodium hydroxide was added and the whole placed in a boiling water-bath for 10 min. (It was found that on boiling for longer periods of time there was no significant increase or decrease in the protein extracted.) The contents of the tube were centrifuged and the sodium hydroxide extract added to 5 ml. of water. The diluted extract was thoroughly mixed and 1 ml. taken and added to 5 ml. of reagent *C* and allowed to stand for 10 min. 0·5 ml. of the diluted Folin–Ciocalteu reagent was mixed with this solution and after 40 min. the extinction of the solution was measured at 750 mμ. A control blank was always used and the results were calculated as μgm. protein per ml. of algal suspension from the calibration curve (Fig. 1). With duplicate samples the error was within 5 per cent.

This work was carried out at the University of Marburg, West Germany.

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Spectrophotometric Determination of Total Carbohydrate

The colour reaction given by anthrone reagent was used for the determination of carbohydrates by a spectrophotometric method. The method used is based on those of Fales[1] and Schlegel[2] but was considerably modified. For example, Schlegel used a wave-length of 570 mμ in order to correct for the presence of pigments in the plant material. But in the technique described here, a blank containing only the plant material (for each determination) and sulphuric acid were used. It was therefore possible to measure the carbohydrate content of the plant material (in this case *Chlorella* cells) at different

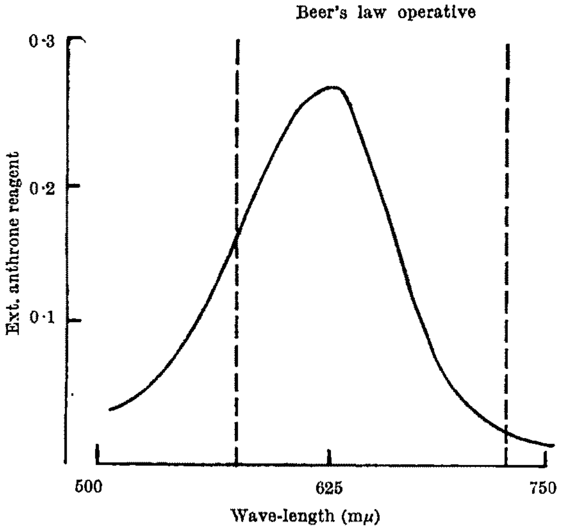

Fig. 1. Extinction of anthrone reagent

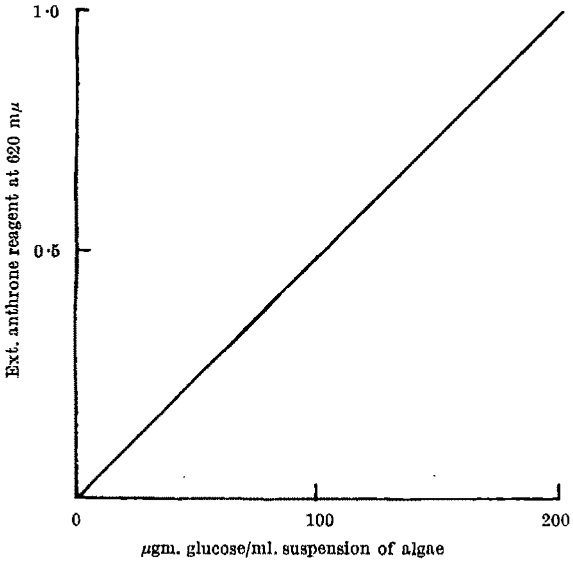

Fig. 2. Calibration curve

stages of growth and when the cells contained different amounts of chlorophyll. Nevertheless, a small but constant error, due to the colour of the anthrone reagent itself, is always present.

The reagent consisted of 0·2 gm. anthrone, 8 ml. absolute alcohol, 30 ml. water, and 100 ml. concentrated sulphuric acid (specific gravity 1·84).

A small volume of algal suspension was diluted five times and to 1 ml. of this suspension 10 ml. of anthrone reagent was added. This was then placed in a boiling water-bath for 7 min. and cooled immediately afterwards. The extinction was measured at 620 mμ (Fig. 1) and the amount of total carbohydrate expressed in μgm. glucose per ml. suspension by using a calibration curve (Fig. 2). A high ratio of reagent to suspension (10 : 1) was necessary because lower ratios did not give a straight-line relationship. The error involved in duplicate samples was less than 8 per cent. This work was carried out at the University of Marburg, West Germany.

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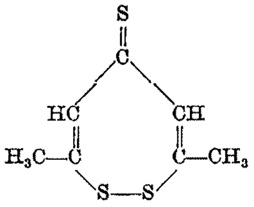
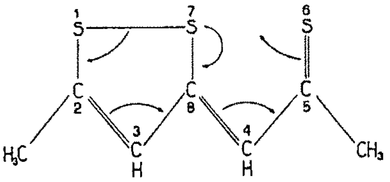
Thio-Thiophthen : an Unusual New Type of Aromatic System

In the present communication we report our preliminary findings in researches on a series of sulphurated cyclic compounds, carried out jointly with G. Traverso of the Physical Chemistry Institute of the University of Pavia.

Arndt *et al.*[1] gave formula I for a compound obtained by treating diacetyl-acetone in benzene solution with phosphorus pentasulphide. From X-ray analysis, we have deduced formula II.



I



II

This structure is characterized by no-bond resonance, which confers an aromatic character on the two rings in full agreement with the properties of the substance[2]. We propose to name this condensed ring system 'thio-thiophthen'.

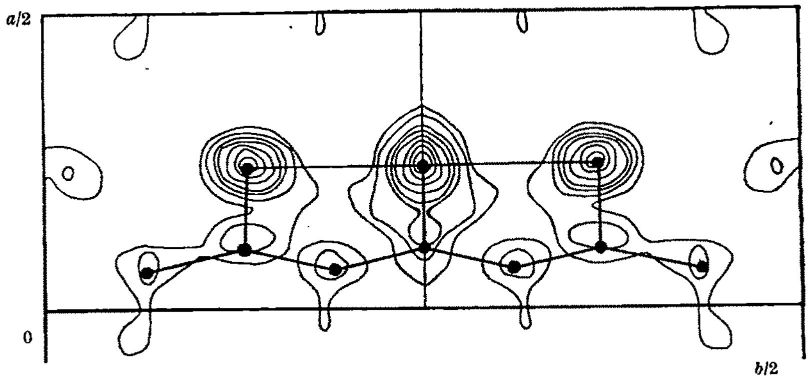


Fig. 1. First electron density projection on (001) : Sayre's equation gave 43 on 68 terms. The indicated positions of atoms are from the first Fourier summation allowing for all structure factors

The substance, prepared by G. Traverso, was crystallized from *tert.* butyl alcohol as thin rectangular or rhomboidal plates. Single-crystal precession and Weissenberg photographs showed an orthorhombic system, space group *Pnma*, with *a*, 7·80; *b*, 20·10; *c*, 5·36 A. and 4 molecules in the unit cell. Observed density, 1·47; calculated, 1·48. Tests of centrosymmetry[3,4] were used to exclude space group $Pna2_1$. Four molecules in the space group *Pnma* require the central sulphur atom and the C_8 atom to be in a special position on the mirror plane at $y = 1/4$.

Every attempt to make the Arndt structure (I) agree with our experimental results, by means of Patterson and Fourier analysis, gave negative results. We succeeded, however, with methods which did not make any assumption about the configuration of the molecule.

Using the Sayre–Cochran–Penfold method[5] we were able to fix the position of atoms, with a reliability index $R = 0·29$ for *hk*0 reflexions and 0·41 for reflexions 0*kl*.

Luzzati's error-curve[6] has confirmed these results, indicating a mean error in the co-ordinates of about 0·10 A. in the first case, and 0·08 A. in the second. Further, the Buerger 'minimum function' method[7] gave maps which agree fully with the previous ones.

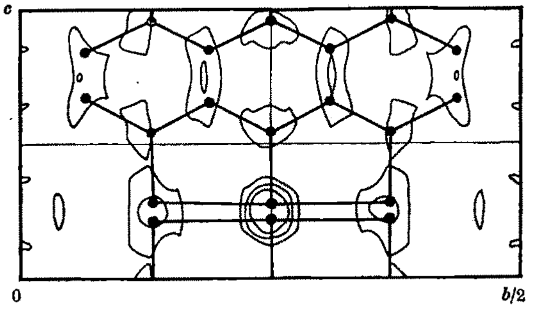


Fig. 2. Buerger's map of the minimum function M_4 (*yz*) on (100). The indicated positions of atoms are from the first Fourier summation allowing for all structure factors

In Figs. 1 and 2 respectively electron-density maps for the plane (001), calculated by Sayre's equation, and for plane (100), obtained by the Buerger method, are shown.

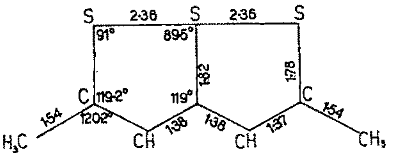


Fig. 3

The molecular shape, shown in Figs. 1 and 2, and the interatomic distances and angles indicated in Fig. 3, are the results of two successive Fourier syntheses, allowing for all structure factors. At the present stage the molecule appears to be quite planar; the C—S distances are less certain than the others. Bond-lengths of 1·37–1·38 A. between the five carbon atoms of the rings characterize the aromaticity of the nucleus. Since the distance between sulphur atoms is 2·36 A., while in compounds of the type[8] *R*—S—S—*R* it is 2·04 A., the S—S bond order is less than unity. The linear system S—S—S is also interesting in relation to the transition state of nucleophilic substitutions to sulphur[9].

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The Electron Affinity of Atomic Oxygen

In a recent communication, Morris and Schmeising[1] applied the empirical extrapolation of ionization potentials of isoelectronic ions to determine the binding energy of the O^- ion (the atomic oxygen electron affinity). By extending the order of the extrapolation through eight isoelectronic ions (to S^{7+}), they find a slightly higher value, 1·044 eV., than is found from the more usual quadratic extrapolation. Stating that experimental determinations of the electron affinity have given results in unresolved conflict, Morris and Schmeising refer to three discordant values. A value of about 2·2 eV. was obtained by a thermodynamic evaluation of the probability of attachment of electrons to atomic oxygen at a hot filament, and from electron impact studies undertaken originally to determine the dissociation energies of molecular nitrogen and carbon monoxide. The value of 1·48 eV. is given by the optical threshold for photodetachment from O^- by Smith and Branscomb. The value of 1·05 eV., which coincides with Morris and Schmeising's extrapolation, was obtained by Schüler and Bingel from the analysis of a certain discrete band spectrum thought to be due to a transition between two bound states of OH^-. (For the original references see Morris and Schmeising[1].) My purpose here is to resolve these apparent ambiguities.

The electron impact experiments referred to by Morris and Schmeising are not now in general in conflict with the photo-detachment value, providing the correct values of the relevant dissociation energies are used in their interpretation. Hagstrum has re-interpreted[2] his results to show the good quality of the agreement. The most precise values for *EA*(O) from electron impact experiments are from the appearance potentials of zero-energy ion pairs in nitric oxide by Clarke[3] (1·47 ± 0·05 eV.) and in carbon monoxide by Lagergren[4] (1·42 ± 0·05 eV.).

The low value of *EA*(O) obtained by Schüler and Bingel depended on the analysis of a band spectrum thought to be due to OH^-. Afterwards, Barrow and Downie[5] produced evidence that the spectrum was due to neutral OH. Schüler and Michel[6] later found an ultra-violet system involving a state in common with their visible system, and both its analysis and excitation potential prove that the two systems belong to the neutral molecule. The observations of Schüler *et al.* have, therefore, no relevance to the properties of O^-.

The photo-detachment experiments on O⁻ have recently been improved[7], with the result that the optical threshold at 8460 ± 30 A. for the transition $O^- \; ^2P_{1/2} \rightarrow O \; ^3P_2 + e$ corresponds to a physical electron affinity of 1·465 ± 0·005 eV., or 33·80 ± 0·12 kcal./mol. The observations of the spectrum are direct and its interpretation unambiguous.

Since the submission of the reply by Morris and Schmeising to these comments, I have re-examined the results of Metlay and Kimball (which gave 2·3 eV. from attachment at a hot filament) in an effort to explain the remaining discordant experimental value for *EA*(O). Metlay and Kimball obtained their result from the solution of Saha's equation for *EA*(O) at each of a number of fixed values of pressure (of nitrous oxide) and temperature (of the tungsten filament). They assumed that O⁻ from the nitrous oxide was the ion which produced the measured current of negative ions. However, if one deduces the affinity of the ion (whatever it may have been) from the reciprocal dependence on temperature (at fixed pressure) of the logarithm of the ratio of currents of electrons and negative ions, one obtains straight-line plots the slopes of which give 3·7–3·8 eV. An impurity with an affinity of 3·7 eV. need only have had a fractional concentration of 6×10^{-4} in the nitrous oxide for the value of 2·3 eV. to have been obtained. The influence on this dependence on temperature of the O⁻ ions (with an affinity of 1·465 eV.) would be entirely negligible. The possibility that the nitrous oxide was contaminated with 0·06 per cent chlorine is suggested by (*a*) the value of the affinity obtained from the dependence on temperature, (*b*) the fact that Metlay and Kimball used 98 per cent pure commercial nitrous oxide purified by distillation, and (*c*) the common commercial processes for production of nitrous oxide generate small quantities of chlorine not easily removed by fractional distillation because of the similar boiling points of the two gases. This suggestion requires experimental proof by mass spectrometry, but it is evident that the data of Metlay and Kimball are internally consistent only if one supposes that the ion observed had a large affinity and small concentration.

The empirical extrapolation methods for finding electron affinities have recently been reviewed[8]. It was found that, of these methods, extrapolation through an isoelectronic sequence of the first excited configuration, proposed by Bates, is the most successful for the elements from boron to fluorine and aluminium to chlorine. However, none of the methods rests on any real theoretical justification for extension from neutral atoms and positive ions, the valence electrons of which move in coulomb fields, to negative ions, where these fields are of short range. Furthermore, the empirical extrapolations are most useful for interpolating the affinities of aluminium, silicon and phosphorus, by arbitrarily adjusting the predictions to agree with the known affinities of carbon, oxygen, fluorine, sulphur and chlorine, for each extrapolation method gives results in error by about 0·5 eV. for these ions. For example, the Glockler extrapolation, used by Morris and Schmeising, when applied to fluorine and chlorine gives 2·93 and 3·05 eV., respectively, and this result is almost independent of the order of the extrapolation. But these values are about 0·7 eV. lower than the known affinities of these gases. If one adds 0·7 eV. to the oxygen affinity predicted by the Glockler extrapolation in quadratic form (that is, interpolating *EA*(O) from fluorine and chlorine) one finds 1·4 eV., in reasonable agreement with the photodetachment results (1·465 eV.). However, the same correction applied to the quadratic Glockler extrapolation for sulphur 'corrects' the affinity from 2·07 eV. to 2·8 eV., while the photodetachment value for *EA*(S) is, by coincidence, just 2·07 eV. Furthermore, Geltman[8] has shown that for some atoms the predictions of the Glockler method are strongly dependent on the order of the extrapolation, and the nature of this dependence varies radically from element to element. Thus, since the extrapolation methods rest on an uncertain theoretical basis, the answer to the question which method is best may require experimental values for so many of the ions that the value of empirical methods for prediction is greatly reduced.

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Branscomb has provided further results in support of a figure of about 1·465 eV. for the first electron affinity of atomic oxygen $E(O \rightarrow O^-)$, and there is strong evidence for this value. However, the difference between this result and the value of Metlay and Kimball[1], $E(O \rightarrow O^-) = 2{\cdot}33$ eV., obtained from electron attachment at a hot filament, still has to be accounted for. In addition, various extrapolation methods[2] give rather lower values than 1·465 eV. for the first electron affinity of oxygen. For example, the extrapolation procedure used by us yielded $E(O \rightarrow O^-) = 1{\cdot}044$ eV., and it seems appropriate to make some comments on this procedure.

The technique employed by us is a development of that due to Glockler[3] and assumes that the ionization potentials *I* of isoelectronic ions satisfy a function f(*Z*) of the atomic number *Z* which is continuous and well behaved. A major disadvantage of the procedure is that the results essentially represent very small differences between large numbers, and they may therefore be subject to considerable uncertainty if the ionization potential data utilized are not accurate. In our application of the method to the case of the electron affinities of oxygen, there was some doubt as to the values of some of the ionization potentials, and the electron affinity values obtained appeared to be the most probable on the basis of the original premise.

To test the general validity of the extrapolation procedure it is applied here to the estimation of the electron affinity of atomic hydrogen, the value of which is known with high accuracy from quantum-mechanical calculations[4]. In this case the requisite ionization potentials for the estimation are known with high precision. The values quoted by Moore[5]

Table 1. IONIZATION POTENTIALS OF IONS ISOELECTRONIC WITH H–

Z	Ion	Ionization potential (I) Moore	Selected value
2	He	24·580	24·580
3	Li^+	75·6193 ± 0·0031	75·6193
4	Be^{2+}	153·850 ± 0·012	153·850
5	B^{3+}	259·298 ± 0·025	259·298
6	C^{4+}	391·986 ± 0·037	391·986
7	N^{5+}	551·925 ± 0·062	551·9336
8	O^{6+}	739·114 ± 0·074	739·157

are listed in col. 3 of Table 1 together with their probable errors. If the data in col. 3 are extrapolated to $Z = 1$, the result for the electron affinity of hydrogen $E(H \rightarrow H^-) = 0{\cdot}7198$ eV. is obtained. However, a difference table shows some 'noise' which may be removed by smoothing the second differences somewhat. Working both ways from the column of smoothed second differences, one can obtain the data listed in col. 4 of Table 1, and extrapolation yields $E(H \rightarrow H^-) = 0{\cdot}7092$ eV. This is in excellent agreement with the value of about 0·71–0·75 eV. obtained by quantum-mechanical calculations. This agreement shows that the premise concerning $f(Z)$ is correct in this case.

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Oxidized Iodine in Sea Water

IN *Nature* of August 3, 1957, p. 250, T. I. Shaw and L. H. N. Cooper suggested that the oxidized form of iodine in sea water is, in all probability, hypoiodous acid and is not iodate, as we believed[1]. We were interested in the reasons for their conclusion; but we cannot accept their view.

First, of three different reactions which determine theoretically the equilibrium of the system (I_2, I^-, IO^- and IO_3^-) in oxygenated sea water:

$$I_2 + OH^- \rightarrow I^- + IO^- + H^+ \quad (a)$$

$$3IO^- \rightarrow 2I^- + IO_3^- \quad (b)$$

$$I^- + \tfrac{1}{2}O_2 \rightarrow IO^- \quad (c)$$

they dismiss reaction (*b*) on the arbitrary assumption that the reaction may be slow because it is trimolecular; then they calculate the ratio hypoiodite/iodide to be unity.

Our experiments have shown that the reaction in question goes smoothly in the given conditions, whereas reaction (*c*) goes on with great difficulty, and, in practice, it can be ignored. Furthermore, experimentally we have reached the conclusion that there is no probability of hypoiodite being detected in sea water.

Table 1

Sample	Phenol added (ml.)	Sodium hydroxide added (ml.)	Iodide-iodine found (μgm. at./l.)	Oxidized-iodine found (μgm. at./l.)
1	0	0	0·15	0·21
2	3	0·5	0·15	0·21
3	6	1·0	0·15	0·21

Our experiments may be summarized as follows:

(*A*) Three different 200-ml. samples of the same sea water were treated with various amounts of 5 per cent phenol solution and 3 N sodium hydroxide solution, and were processed according to our method of iodine determination[2]. If the original sea water had contained hypoiodite, it would have been decomposed by the phenol treatment, giving a smaller value for the oxidized iodine[3]. The results in Table 1 show that, contrary to Shaw and Cooper, the oxidized iodine was not in the state of hypoiodite.

(*B*) 1 litre of a sea water sample was put in a stoppered bottle with iodine and shaken for 1 hr. (1) 20 ml. of the solution thus obtained was titrated with 1/500 N thiosulphate solution. The titre, which corresponds to free iodine and the hypoiodite formed from it, was 4·5 ml. Then the solution was acidified with 3 ml. of 3 N hydrochloric acid. Iodine was liberated and consumed an additional 1·0 ml. of the thiosulphate solution, which corresponds to iodate originating in hypoiodite. (2) Another 20-ml. portion of the solution was acidified and titrated; the thiosulphate solution consumed was 5·5 ml. (3) After the addition of potassium iodide, another 20-ml. portion was treated as in (2), and this required 5·5 ml. thiosulphate. (4) To another 20 ml., 2 ml. of a 5 per cent phenol solution was added: the orange colour of the solution disappeared. After 3 min. the solution was acidified with hydrochloric acid and the solution became tinged with yellow, pointing to the liberation of iodine, which consumed 1·0 ml. of the thiosulphate solution. It is evident that hypoiodite directly, and free iodine indirectly via hypoiodite, were removed by phenol, leaving untouched the iodate which first liberated iodine by acidification. (5) Another 20 ml. was treated with phenol and sodium hydroxide solution; this required 1·0 ml. of thiosulphate solution. (6) Portions were treated as in (1) after lapses of 1–25 days. With time, the amount of thiosulphate solution required for the first titration gradually decreases, with a corresponding increase in that required for the second titration. This shows that the velocity of reaction $3IO^- \rightarrow 2I^- + IO_3^-$ is high (see Fig. 1).

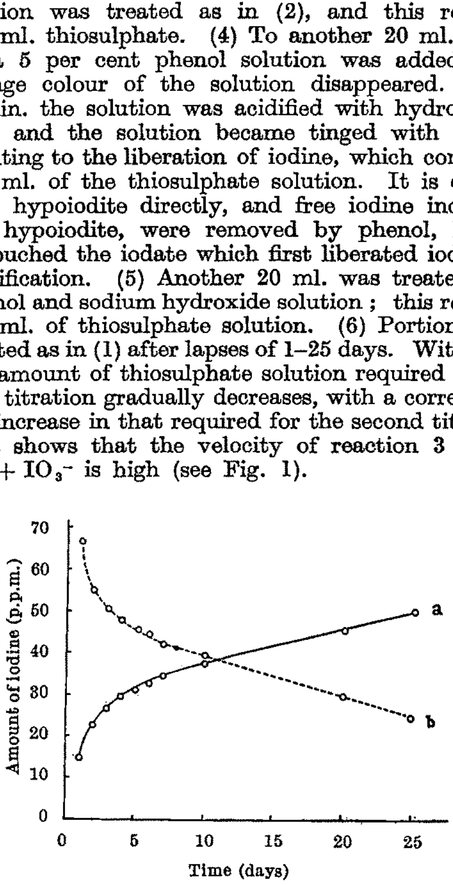

Fig. 1. (*a*) Iodate curve; (*b*) hypoiodite curve

Summarizing the experimental results: (1) there is no detectable amount of hypoiodite in sea water; (2) the system iodine, iodide, hypoiodite and iodate reaches a thermodynamical equilibrium rather quickly with iodide and iodate ions as predominant components; (3) even in the presence of oxygen, the oxidation of iodide to a higher oxidized state does not occur easily; otherwise iodate would be only one possible state of iodine in an oxygenated sea water. For reasons (2) and (3), iodine in sea water remains in practice in two states, namely, iodide and iodate.

Shaw and Cooper's view that the ratio of hypoiodite to iodide is unity is thus untenable: as a matter of fact, even if the values are limited to those of the off-shore waters of Honshu[1a], to which they refer, the ratio varies from 0·88 to 1·75 with an average of 1·43, a value which cannot be easily made unity in round figures when the accuracy of determination is taken into consideration. Furthermore, among our later results from other regions[1b], which were apparently not available to them when formulating their views, we find many extreme values such as, for example, those for the 0 m. sample from station Satsuma 29, lat. 03° 38′ N., long. 141° 56′ E., 0·00 μgm. atom iodate-iodine/litre and 0·06 μgm. atom iodide-iodine/litre with iodate-iodine/iodide-iodine = 0·00, while for the 0 m. sample from station Satsuma 5, lat. 13° 54′ N. and long. 150° 57′ E., iodate-iodine and iodide-iodine are respectively 0·21 μgm. atom/litre and 0·04 μgm. atom/litre, with the ratio iodate-iodine/iodide-iodine equal to 5·2.

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WINKLER[1] has demonstrated that a substantial part of the iodine naturally present in sea water is in an oxidized form which he considered to be iodate. I have suggested that the bactericidal nature of sea water towards coliforms is due to the presence of this iodate[2].

Shaw and Cooper[3] have recently published a communication on the mechanism of iodine oxidation in sea water in which they demonstrate thermodynamically that aerial oxidation of iodide would take place at the *p*H of sea water. They recognize that the thermodynamically stable form of oxidized iodine at this *p*H is iodate, but on the grounds of the third-order kinetics of the hypoiodite–iodate conversion, and the presence of biological activity, claim that iodate would not be formed. They consider that the oxidized form of iodine present would be an equilibrium mixture of iodine and hypoiodous acid (hypoiodite).

My work on the coast of New Zealand is not in agreement with these views, as the experimental evidence indicates that the oxidized form of iodine present in the local sea water is iodate, with no evidence for the presence of a detectable amount of hypoiodite. This experimental evidence is briefly as follows.

(*a*) Upon the addition of excess iodide to local sea water, a formation of the triiodide ion is not observed spectrophotometrically at 356 mμ, or by the formation of a blue colour with starch, unless the solution is, in each instance, first acidified. If, as according to Shaw and Cooper, the iodine was present as hypoiodite, then the above reactions would have been given without acidification. Solutions of iodate of equivalent concentrations to that found in sea water react only when acidified.

(*b*) When the amount of oxidized iodine is estimated as above, the concentration of oxidizing material found is too great to be other than iodate. In my earlier paper I showed that the amount of oxidizing material was equivalent to 150 μgm./litre of iodine, that is, the amount of iodate which would be formed from 25 μgm./litre of iodine, which is in agreement with the observations of Winkler[1] and others[4]. If this amount of oxidizing substance were hypoiodous acid or hypoiodite, then it would need to have been formed from 75 μgm./litre of iodine, which is more than is usually regarded as being present.

In the light of the above evidence I consider that the local sea water contains iodate. Sulphamic acid was used for the acidifications as it effectively prevents interference from nitrite.

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TAKEN together, Sugawara and Terada's experiment *A* and Johannesson's evidence form more cogent reasons for believing iodate to be the oxidized form of iodine in the sea than the reasons we presented for believing hypoiodous acid to be the oxidized form. However, as we indicated, the volatility of iodine from sea water seems to demand that a large part of the iodine should be in the form of hypoiodite. Unless the volatility can be explained quantitatively in terms of an iodate–iodide mixture, the state of iodine in the sea cannot be considered as satisfactorily settled.

Moreover, we find that whereas Sugawara and Terada's conclusions upon the rate of oxidation of iodide in the sea are doubtful, their conclusions upon iodide–iodate–hypoiodite equilibration have slender experimental foundation.

First, if iodide oxidation in the sea were as slow as Sugawara and Terada's laboratory experiment—and one that we have made—suggest, then we should expect that turbulent mixing would prevent variations in the amount of oxidized iodine between neighbouring portions of sea water. Sugawara[1], however, has presented results showing that the amount of oxidized iodine varies between samples taken simultaneously at the same station but differing in depth by only a few metres. He finds, for example, at the surface on station 1 a total concentration of iodine of 41·3 μgm./litre and a concentration of iodide of 15·8 μgm./litre, whereas at 10 m. the total iodine is 41·4 μgm./litre but the iodide 18·0 μgm./litre. The lowest value for the eddy diffusion coefficient in Kuroshio water is given[2] as 7 gm. cm.$^{-1}$ sec.$^{-1}$; whence, in the absence of known biological accumulators of iodate, it would appear that, to achieve or maintain this difference, at least some 7 per cent of the iodide in the sea there undergoes oxidation daily while a somewhat similar fraction of the oxidized form undergoes reduction. To attribute the variations solely to rapid reductive processes would be unsound, since these would lead to iodide being the sole marine form of iodine.

Secondly, in experiment *B*, where Sugawara and Terada followed the time course of the conversion of 'hypoiodite' to iodate, it was not obvious to us whether the progressive slowing of the reaction was due to an approach to equilibrium or whether it represented solely the kinetics of the forward reaction. If equilibrium is being approached, then a back reaction of iodate and iodide should occur and give hypoiodite with accompanying iodine. To examine this we have added to filtered sea water a mixture of potassium iodide and iodate (molecular ratio 5 : 1) to give a total iodine concentration of 5×10^{-4} gm. atoms/litre. One sample was kept in the light, another in the dark. After 13 days, starch solution was added; but no blue colour developed, although a test showed that $0{\cdot}08 \times 10^{-4}$ gm. atoms/l. (1 p.p.m.) iodine would have been detectable. It seems clear, therefore, that the back reaction is negligible and that Sugawara and Terada's results represent solely the forward kinetics of iodate formation. Thus their second summarizing statement is without experimental foundation. We note that their results indicate a second- or higher-order reaction with respect to 'hypoiodite'—and if even second-order kinetics persist to the thousand-fold greater dilution at which iodine occurs naturally in sea water, then not more than 1–2 per cent of 'hypoiodite' would be dismuted to give iodate annually.

If the several observations are sound and to be reconciled, it seems that there remains to be uncovered some unrecognized process or compound involving iodine at concentrations of about 10^{-7} *M* in sea water.

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Are Tektites Extra-Solar-System Meteorites?

RECENT communications to *Nature*[1] indicate that the origin of tektites is still a mystery. New evidence supporting an extra-terrestrial origin has been obtained by Ehmann and me[2]; we have found radionuclides induced by cosmic rays (aluminium-26 and beryllium-10) in some tektites (australites and Libyan Desert silica-glass) at levels comparable to those observed in stone meteorites and considerably above any conceivable levels of production by cosmic or terrestrial radiations at or beneath the Earth's surface. This finding practically eliminates not only the Earth, but also the Moon, as the source of tektites, since the bulk of lunar material expelled in collisions of giant meteorites with the Moon[1] would undoubtedly originate at depths of at least several metres, where the cosmic radiation would be negligible in intensity. Although these findings require confirmation and more adequate controls, it will be assumed in the following that tektites are glass meteorites from outside the terrestrial system.

The best defined fields of tektites range in size from approximately 53 km. × 130 km. for the Libyan Desert silica-glass to about 2,000 km. × 3,000 km. for the australites[3]. These areas are much greater than those occupied by the fragments of meteorites forming meteorite showers, indicating that the tektites of a given occurrence cannot be fragments of a single meteoroid which was shattered in the Earth's atmosphere. They must, then, have arrived at the Earth as a loose cluster of glassy objects.

On the other hand, in all known cases of loose clusters of small objects in the solar system (disrupted comets, meteor showers), dispersal through much greater distances than the Earth's diameter occurs in times of the order of one period or less. Urey[4] first emphasized the impossibility that self-gravitation could hold together for any appreciable time, against the disrupting influence of the Sun's gravitational field, clusters of such low density as would be necessary according to the meteoritic interpretation of tektites.

The hypothesis that the tektites have arrived as clusters of objects from outside the solar system provides a way out of these difficulties. Thus, the clusters would not have had to survive the local disruptive forces for long, and they could easily escape the regions of greatest gravitational-field gradients close to the Sun and major planets. Such a cluster of solid objects travelling through interstellar space would have collapsed into a small volume with the individuals touching one another, and a limited exposure to the disruptive forces experienced upon arrival in the solar system may explain the low density of the cluster on arrival at the Earth. The Earth's own gravitational field may be significant or even sufficient in this respect.

Using available data[3] to estimate the probable mass before fall in an individual tektite occurrence, it can be calculated roughly that, if tightly packed, about one-quarter would be strongly irradiated by cosmic rays, another one-fifth would receive moderate irradiation, and the rest would be effectively shielded. The extent of exposure would be even greater if the aggregate were loosely packed and irregular in shape. Thus an appreciable fraction of the objects should contain significant levels of induced radioactivities at the time of fall. Moreover, there should be variations in level of activity from specimen to specimen and probably regional variations over the tektite fields, so that experimental testing of the compact-cluster hypothesis is possible.

An extra-solar-system origin of tektites may also be subject to experimental verification, through isotopic analysis of the constituent elements. In view of the apparently widespread occurrence in the universe of synthesis or modification of elements, of the apparent variety of processes participating in this activity, and of the apparently continuing level of such activity[5], it is quite likely that matter formed elsewhere than our own may have different isotopic composition of some or many of its elements. Even if the processes were the same, if the times were different there would be differences in the abundances of the shorter-lived primary natural radionuclides (especially uranium-235 and potassium-40); and some extra-solar-system matter should contain locally extinct radionuclides of shorter life-time (such as curium-247, plutonium-244, uranium-236, lead-205, samarium-146, iodine-129, etc.).

H. Suess[6], from considerations similar to the above (though not regarding the tektites to be of different origin from the meteorites in general), measured the specific potassium-40 radioactivity of potassium from several tektites and meteorites. None of the samples differed significantly from terrestrial potassium, leading to the presumption that the elements in tektites and meteorites were formed by the same mechanism and at the same time as those of the Earth. However, the measurements were of low precision and gave no information on the ratio of stable isotopes. Altogether, very little is known about the isotopic composition of the elements in tektites, which may constitute our first and only accessible samples of matter from outside the solar system. Burbidge *et al.*[5] point out the decisive importance for problems of stellar nucleogenesis of information on the isotopic composition of elements from other parts of the universe.

A non-solar-system nature of tektites would lessen the difficulty of explaining their failure to fit into the system comprising the recognized types of meteorites. Moreover, it opens for speculation (and experimental testing) a wide variety of possible origins not possible under the restrictive assumption that they are members of the solar system.

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Behaviour of the Present Sunspot Cycle

THIS communication deals with the sunspot numbers during the years 1944–57, and gives a forecast for the years 1958 and 1959. It is part of a research on the behaviour of sunspots since 1863 that will be published in due course.

Monthly and annual averages of sunspot numbers have no heliophysical meaning, because the month and the year have nothing to do with the Sun. The only acceptable average is that based upon the solar rotation with its synodical period of 27·2753 days (see, for example, Nautical Almanac, 1958). It must be remarked, however, that this figure is not as accurate as is suggested by the four decimal places, since the Sun's rotation is variable, depending upon the heliographic latitude. This value has, however, been adopted in order to link the present results with this average solar rotation. For the whole period from 1899 to March 1958, running 27·275-day averages have been calculated, in such a way that the difference between the calculated day and the theoretical one never exceeded one day.

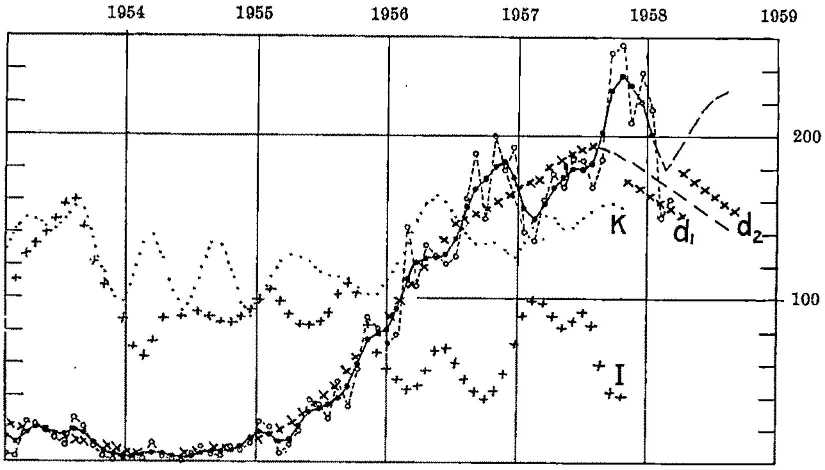

Fig. 1

Waldmeier's method of smoothing through 13 months (applied for the first time by Wolf in 1872) is not adequate, 13 months being too long. In the present investigation the smoothing method $(R_1 + 2R_2 + R_3) : 4$ has been applied. In this way a new row of figures is obtained and the same procedure may be applied again and so on. Hence smoothed rows based upon 4, 5 and more original figures are obtained. This has been continued with up to five original R's, which gives quite acceptable results. These are represented by the formula:

$$R_m = (R_1 + 4R_2 + 6R_3 + 4R_4 + R_5) : 16$$

If the values obtained are compared with those of Waldmeier the advantages of the method used are obvious.

Figs. 1 and 2 contain the following curves: *a*, the average value of R for each rotation of the Sun, at the first day of the rotation; *b*, the smoothed curve R_m; *c*, the smoothed monthly values of Waldmeier; d_1 and d_2, two of Waldmeier's predictions, for October 1957 and March 1958; *K*, the smoothed magnetic character figures after Bartels for Witteveen (Netherlands); *I*, the smoothed ionospheric index for De Bilt (Netherlands).

The curve *b* shows an outstanding series of secondary waves, especially in the neighbourhood of the sunspot maxima. This feature is common to all sunspot cycles investigated hitherto. The amplitudes are large enough to be statistically significant. The curve *c*, Waldmeier's smoothed curve, is obviously inaccurate; its secondary waves, 1948–50, are definitely opposite to those of curve *b*, a feature obvious in all sunspot cycles investigated. This behaviour is caused by the factor mentioned above: the epoch of Waldmeier's extremes is strongly influenced by the long interval of 13 months. Waldmeier has especially emphasized a secondary maximum of 148·5 in October 1948. It coincides with a

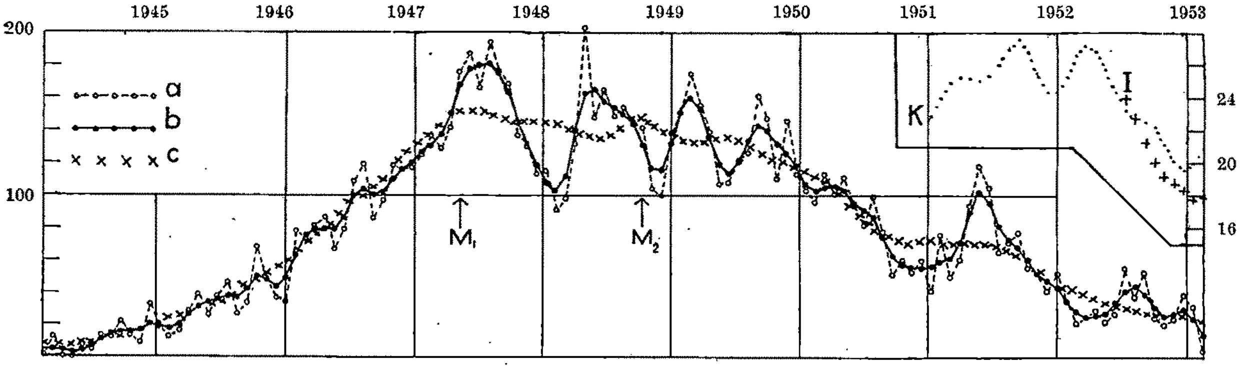

Fig. 2

minimum in the new curve. His high value is caused by the two secondary peaks on both sides.

Each month Waldmeier gives a prediction of his smoothed values of R for the coming half year. Two of these predictions have been plotted in Fig. 1 (d_1 and d_2). His maximum was in August 1957, with a smoothed value of 193·9. Without violating his curve it may be continued just between his two rows of predicted points.

The maximum of the new curve was reached in October 1957. The first secondary maximum may be expected about June to August 1958. A minimum in the rotational average was reached in March 1958 ; the sunspots then rose again, passing 300 at the end of March. The second secondary maximum must follow in the first half of 1959. It should be emphasized, however, that neither the heights nor the epochs of these maxima can be fixed exactly.

As regards the magnetic character, K, and the ionospheric index, I, calculated in the same way as the curve b, their course is fairly independent of the sunspot curve. During the whole of the rapid rise of the sunspot curve in 1957 both K and I were pretty well constant. Apparently both phenomena depend upon the occurrence of solar eruptions which do not by any means run parallel to the sunspots.

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Direct Measurement of the Velocity of Propagation of a Ferromagnetic Domain Boundary in 'Perminvar'

MEASUREMENTS of the velocity of propagation of a ferromagnetic domain boundary were first carried out in the well-known experiment of Sixtus and Tonks[1]. Afterwards, Williams *et al.*[2] were able to measure the velocity of a single domain wall observed to exist in a [100] 'picture frame' single crystal of 3·5 per cent silicon-iron. These measurements were later extended to ferrite single crystals[3] and to polycrystalline 65 per cent nickel–iron made pseudo-single crystalline by annealing in a magnetic field[4].

All these measurements are indirect in so far as they are obtained by applying a sudden change in field and recording the value of dB/dt from the e.m.f. induced in a secondary coil. The wall velocity is then determined from the observed maximum value of the dB/dt pulse (or its integrated value) and the domain geometry as observed under static conditions by Bitter patterns.

Using a modification of the Kerr magneto-optic effect described by us[5], we have succeeded in measuring directly the velocity of the domain wall in magnetically annealed 'Perminvar' (composition, per cent : nickel 45, iron 30, cobalt 25) kindly supplied by the Post Office Research Station, Dollis Hill, London, in the form of an annular ring 1 in. external and 3/16 in. internal diameter and 147 microns thick. Observations using the Kerr effect showed that a large part of the total change in magnetization took place by radial movement of a single circular wall from the inside edge outwards. The modification of the original apparatus consists simply in using a double slit instead of a single slit as the source of illumination, focused so as to give on the surface of the specimen a light probe consisting of two rectangular images separated by a distance of 1·45 mm. The reflected light was received by a photomultiplier after transmission through a single-layer 'Polaroid'. The light intensity incident upon the photocathode then changes suddenly as the wall moves across the two images forming the light probe, and the photomultiplier output is observed on an oscilloscope as a double step. Using single-sweep operation with a calibrated time-base, the oscilloscope traces were photographed and the time taken for the wall to pass across the light probe was calculated. Fig. 1 shows a typical output trace.

A complete set of measurements in which the velocity of the wall ranges from 0·2 to 80 cm./sec. is shown in Fig. 2. For small driving fields the velocity obeys the relation :

$$V = G(H - H_c)$$

in which H_c is a critical field-strength necessary to maintain movement of the domain wall. H_c was

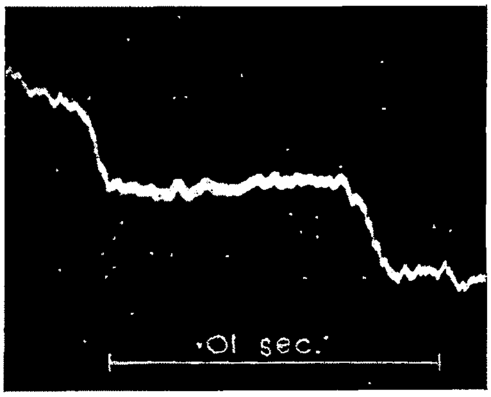

Fig. 1

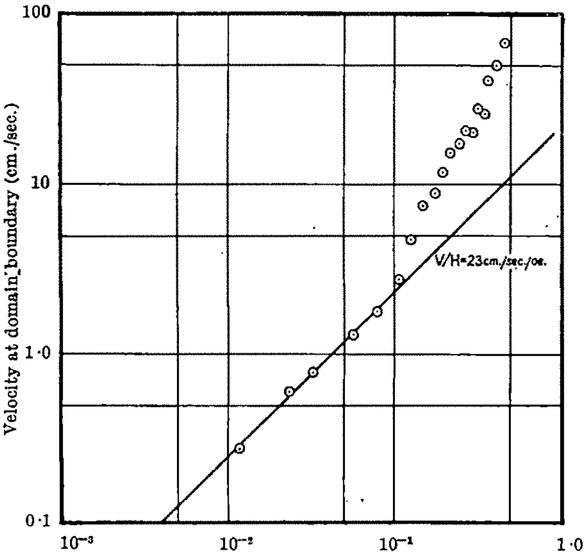

Fig. 2. Velocity of the domain boundary as a function of the excess field. The value of the excess field decreases from the inside of the specimen outwards, and H is the field at a point midway between the double light probe. The measurements are not corrected for this variation of the field

found to be 0·108 oersted. In the theoretical approximation in which the wall remains plane and relaxation effects are ignored:

$$G = \frac{\pi\rho F}{128 I_s d}$$

in which I_s is the spontaneous magnetization, ρ the electrical resistivity, d the thickness of the specimen and F is a numerical factor equal to 1·06 for a specimen of the dimensions used here. Taking $I_s = 1{,}200$ gauss, $\rho = 1{\cdot}86 \times 10^4$ e.m.u., the calculated value of G is 27 cm./sec./oersted, which agrees well with the measured initial slope of the V *vs.* $(H - H_c)$ curve, namely, 23 cm./sec./oersted. The very small discrepancy between these two values, which may be due to the neglect of relaxation effects, indicates that the velocity of the domain wall is limited almost entirely by eddy currents.

It is proposed to extend these experiments, and a fuller account will be given later.

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Aluminium Nitride Precipitates in α-Iron

AN investigation which we have carried out provides more detailed information concerning the morphology of aluminium nitride precipitates formed in an α-iron matrix than that recently reported by Hsiao[1].

We employed a vacuum-melted alloy containing 1 per cent aluminium (ingot U of the Sloman and Evans aluminium deoxidation series[2]) made by adding 1 per cent of aluminium and 0·5 per cent of oxygen to iron of composition:

Carbon	0·0045 per cent	Phosphorus	0·004 per cent
Silicon	0·002 ,,	Nickel	0·001 ,,
Manganese	0·002 ,,	Copper	0·012 ,,
Sulphur	0·0048 ,,	Magnesium	0·0005 ,,

It was nitrided in dry ammonia gas for 5 hr. at 640° C. and cooled in the furnace. This treatment produced a nitrogen concentration gradient which extended inwards from the surface of the specimen for about 0·035 in. Examination by optical microscope of the inner portion of the nitrided zone showed a poorly resolved, mottled structure. (Any areas that contained colonies of finely dispersed aluminium oxide inclusions were avoided during the examination.)

Using the single etch extraction replica technique[3], precipitates were isolated from the nitrided zone in dry-stripped 'Formvar' replicas after etching the specimen for 3 min. with 10 per cent 'Nital' and examined by electron microscopy. The innermost portion of this zone contained two types of precipitate, namely, (*a*) long, narrow rods about 0·05μ across and up to about 4μ in length, and (*b*) small angular particles up to about 0·1μ across (Fig. 1). The method of selected area transmission electron diffraction available with a Metropolitan-Vickers type *EM*3 electron microscope enabled patterns to be recorded from each type separately. In both

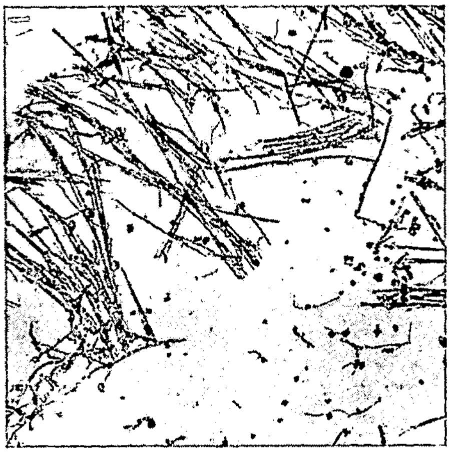

Fig. 1. Rod-like and angular aluminium nitride precipitates isolated from a nitrided iron – 1 per cent aluminium alloy in a 'Formvar' extraction replica. Electron micrograph, × 8,000

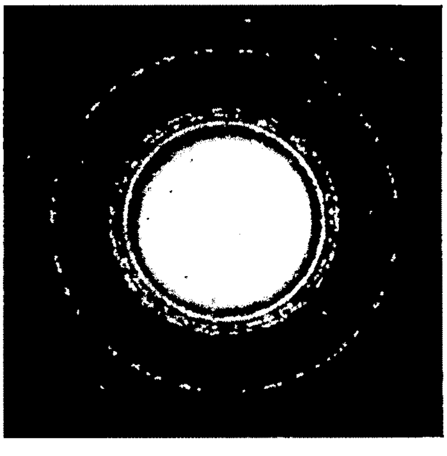

Fig. 2. Aluminium nitride transmission electron diffraction pattern obtained from both types of precipitate shown in Fig. 1

Table 1

Observations			Data for aluminium nitride*	
Ring diameter (cm.)	Corresponding d (A.)	Relative strength	d (A.)	Relative strength
2·59	2·71	S	2·70	90
2·80	2·50	M	2·49	80
2·95	2·38	M	2·36	90
3·84	1·83	MW	1·83	50
4·52	1·56	M	1·56	100
4·99	1·41	MW	1·42	100
5·20	1·35	MW	1·35	40
5·30	1·33	MW	1·33	100
5·40	1·30	MW	1·31	70
5·96	1·18	W	1·19	50

* ASTM X-ray Data Card No. 3-1144.

instances, the full aluminium nitride (AlN) pattern was obtained (Fig. 2 and Table 1). No additional lines were present.

A similar examination of areas within the mottled zone nearer the surface, and therefore having a higher nitrogen content, revealed a dense array of rod-like precipitates, finer than those shown in Fig. 1, that again gave electron diffraction patterns wholly characteristic of aluminium nitride. No angular particles were present.

These observations suggest that rod-like particles are the characteristic form of precipitation of aluminium nitride in an α-iron matrix. Unless there is interference from other elements present, this is also likely to be the characteristic form of aluminium nitride occurring in steels.

Hsiao[1] has isolated small particles up to 0·08μ across in a 'Formvar' replica dry-stripped from a nitrided steel containing 0·035 per cent aluminium after etching the specimen surface for about 15 sec. with 1 per cent 'Nital', and has assumed them to be aluminium nitride. Although they appear somewhat similar to the type (*b*) aluminium nitride precipitates of Fig. 1, other considerations suggest that they may not have been correctly identified. Thus, neither the rod-like nor the angular form of the aluminium nitride precipitates isolated from the nitrided iron – 1 per cent aluminium alloy exhibited signs of attack after severe etching with 'Nital', whereas Hsiao[1] has reported that many of the particles reputed to be aluminium nitride were dissolved during the mild 'Nital' etch given to effect isolation. The uncertainty associated with Hsiao's identification of the extracted particles could, however, be resolved if transmission electron diffraction studies were made directly on the particles in the extraction replica instead of inferring their identity from reflexion electron diffraction studies made on the etched metal section.

The information given above relating to the morphology of aluminium nitride precipitates was briefly reported at the annual conference of the Electron Microscopy Group of the Institute of Physics held at Bangor in September 1957. A fuller account of the work is to appear elsewhere. Thanks are due to Mr. R. A. Hacking, director of research, for permission to publish this communication.

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Formation of Prostaglandin *in vitro*

THE contracting power of smooth muscle in seminal fluid and in extracts from prostatic and vesicular glands was described independently by von Euler[1] and Goldblatt[2]. The biological and chemical characteristics were further studied by von Euler[3]. The active principle, prostaglandin, was shown to be an organic, unsaturated acid without nitrogen. *In vivo* and *in vitro* it produced an increased tone and motility in many smooth muscle organs, for example, in the uterus and the intestine. Highly purified preparations of prostaglandin have a contracting effect on smooth muscle of isolated duodenums of rabbits comparable with that of acetylcholine[4]. The active principle has hitherto been found only in secretions and extracts from the prostatic and vesicular glands from man and sheep. More recently, other naturally occurring substances with similar biological and chemical characteristics have been described[5].

In the present series of experiments the active principle is extracted from organs or seminal fluids with two volumes of acidified acetone (1 ml. 3 N hydrochloric acid per 100 ml. acetone). After evaporation of the acetone under reduced pressure, the active factor is extracted from the aqueous phase by shaking thoroughly with ethyl acetate at a *p*H less than 3. The factor is then extracted by shaking vigorously with 0·15 M phosphate buffer at a *p*H greater than 7·5.

Biological assay was performed on the isolated, atropinized duodenums of rabbits in a 15 ml. organ-bath. The Tyrode solution was aerated with 6·5 per cent carbon dioxide in oxygen. Most of the preparations were also tested by rabbit's blood pressure. One unit per litre of bath fluid gives a definite effect on the isolated duodenum of the rabbit. Prostatic glands from man and vesicular glands from sheep contain about 3–5 units prostaglandin per gm. of organ. Seminal fluid, however, contains 30–50 units prostaglandin per ml. In the first experiments seminal fluid was left standing at room temperature; this caused no change in the content of prostaglandin. In a second series of experiments the vesicular glands from sheep were homogenized in two volumes (v/w) of 0·15 M phosphate buffer at *p*H 7·15. The homogenate was incubated at 38° C. with continuous shaking for varying periods. The reaction was stopped by adding two volumes (v/v) of acidified acetone and the active factor was then extracted as above. In these experiments 1 gm. of organ yielded up to 50 units prostaglandin (Fig. 1).

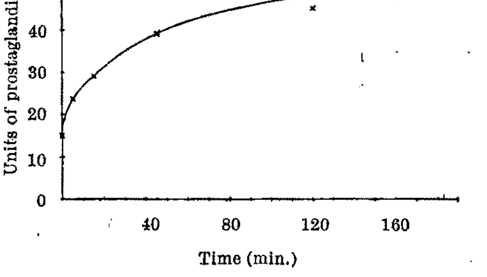

Fig. 1. Vesicular gland from sheep. Homogenized and incubated in 0·15 M phosphate buffer at *p*H 7·15. Temperature, 38° C.

Vogt[6] has shown that when lecithin from egg yolk is incubated with lecithinase *A*, a fatty acid, with a contracting action on smooth muscle resembling that of prostaglandin, is split off from the lecithin molecule. Francioli[7] has demonstrated lecithinases in prostatic glands of different species. The effect of lecithinase *A* on the formation of prostaglandin *in vitro* was therefore tested.

As source of the enzyme, venom from *Naja naja* (cobra) was used. 10 μgm. of venom per ml. buffer in an incubation experiment similar to that described above increased the formation of prostaglandin (Table 1).

It is known that the histamine liberator 48/80 releases not only histamine but also a slowly reacting substance[8]. When 48/80 was used in the prostaglandin experiments, however, it definitely inhibited the formation of prostaglandin (Table 1).

Table 1. EFFECT OF INCUBATION ON PROSTAGLANDIN CONTENT OF VESICULAR GLAND OF SHEEP. ORGANS HOMOGENIZED AND INCUBATED AT 38° C. IN 0·15 *M* PHOSPHATE BUFFER AT *p*H 7·15

Substances added	Units of prostaglandin per gm. gland		
	Non-incubated	Incubated 1 hr.	Incubated 2 hr.
Without addition	2·5	25	40
Cobra venom, 10 μgm./ml.		60	80
48/80, 10 μgm./ml.		15	20

Thus prostaglandin can be liberated from the vesicular gland of sheep in amounts which correspond to that found in seminal plasma. This formation can be enhanced by lecithinase *A*, and inhibited by 48/80. The reactions involved in the formation of prostaglandin are under investigation and will be published elsewhere.

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Potassium Atractylate, a New Inhibitor of the Tricarboxylic Acid Cycle

THE roots of *Atractylis gummifera*, a Mediterranean member of the Compositae called "masticogna" in Sicily and "musciurida" in Sardinia, contain potassium atractylate, which is a glycoside the aglycone of which is not yet chemically known though it can be obtained in crystalline form[1].

The pharmacological properties of the roots of *Atractylis gummifera*, called *Camaeleon niger*, were well known in classical times and are referred to in Dioscorides' "De Materia Medica". These therapeutic properties have been almost completely forgotten, however[2]. We have recently been engaged in testing the pharmacological activity of potassium atractylate[3].

In the present communication the results of investigations carried out in animals are summarized. Potassium atractylate injected into mice, rats, rabbits and dogs at first causes hyperglycæmia (until the reserves of glycogen in the liver and muscles are exhausted), then hypoglycæmia with typical convulsions, acidosis (probably by increasing the concentration of lactic acid in the blood), and diminished oxygen consumption.

The sensitivity of the animals to the toxic action of the drug undergoes seasonal variations; thus 5 mgm./kgm. body-weight injected intravenously is sufficient in winter to kill a dog, whereas in summer a dose 4–5 times larger is necessary.

Convulsions disappear after administration of glucose, but the animals die in a state of deep depression, even after administration of bicarbonate in order to prevent acidosis. Thus, the metabolic block seems to be irreversible. The resynthesis of the glycogen of liver and muscles is inhibited, whereas the glycogen content of the heart is either not modified or is even increased.

Potassium atractylate seems to act at the level of the tissues, since it diminishes the oxygen consumption and inhibits the synthesis of glycogen by the isolated rat diaphragm and since oxidation of liver homogenate is inhibited by very low concentrations (3·5 × 10^{-6} *M*) of the drug. It is probable that potassium atractylate inhibits selectively the tricarboxylic acid cycle as it reduces the oxygen consumption of the isolated mitochondria at the same rate as it does in the homogenate. A strong inhibition of the synthesis of adenosine triphosphate has also been demonstrated directly by chromatographic determination.

It seems to be important to point out that the rate of oxidation of pyruvic and ketoglutaric acids is more depressed than that of oxalacetic acid, and that the uptake of phosphate is much more depressed than might be expected from the corresponding depression of oxygen consumption (in the oxidation of ketoglutarate in the presence of potassium atractylate the ratio phosphorus/oxygen is 0·86).

It seems likely that in the inhibition of the tricarboxylic acid cycle by atractylate, the systems regulating oxidative decarboxylation and phosphorylation are particularly involved.

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Intracellular Changes in Levels of Polarographically Active Sulphydryl Groups in Rat Liver during Carcinogenesis

THE relationship of SH- and SS-groups to growth processes has been the subject of much research[1]. An increase in the concentration of SH-groups was usually associated with the mechanism of mitosis[2]. Since the observations of Hammett[3] and Voegtlin[4] the relatively high rate of cell division in tumours has been reported to be connected with greater amounts of glutathione in malignant tissue. Measurements

Table 1. Polarographic Test for Reduced Glutathione in Homogenized Liver during Carcinogenesis

These results refer to height (cm.) of polarographic anodic wave ($2GSH \rightarrow GSSG + H_2$) as shown directly in the homogenate containing approximately 100×10^6 units of deoxyribonucleic acid (0·5 mgm./cm.^{3})*. '*LKB*-Blomgren' polarograph, type 3266, attached to Leeds Northrup automatic recorder ('Speedomax' type *G*). Sensitivity: 10 m.amp. for full deflexion of the galvanometer. 1 cm. = 66 μgm. GSH in 1 ml.

Tissue	Normal liver	Liver fed basal diet		Liver fed 3′-methyl, 4-dimethyl aminoazobenzene								Novikoff hepatoma
Time (days)		30	180	30	60	80	100	110	150	180	210	
Value (cm.)	10·8 (5 determ.)	9·9	8·4	11·9	12·0	11·0	7·0	5·4	3·8	4·0	2·56	1·84 (5 determ.)

* DNA unit = DNA content of diploid rat nucleus = 5×10^{-12} gm. 100×10^6 DNA units = $0·5 \times 10^{-3}$ gm.

by Greenstein of the glutathione content of spontaneous and transplantable hepatomas indicated values some 10 per cent and 24 per cent lower than those of normal liver on a wet-weight basis[5].

Work performed recently in this laboratory was concerned with the question whether there are any consistent changes in the level of free, non-protein, sulphydryl groups during the 200-day period needed for development of liver tumours in Sprague–Dawley rats fed with the carcinogenic azo-dye, 3′-methyl, 4-dimethyl aminoazobenzene (0·6 per cent in a basal diet poor in riboflavin). The polarographic method was chosen because it allows ready observation and recording of changes in SH-compounds. Two tests were used: anodic oxidation of reduced glutathione ($2 GSH \rightarrow GSSG + H_2$), which gives an anodic wave at a potential[6] of +0·5 V. and can be used directly in the homogenate under nitrogen[7], and, second, Brdička's catalytic increase of cathodic current which occurs in presence of cobaltous and cobaltic ions in ammoniacal solutions. In the latter test the non-protein SH- and SS-groups give this reaction only in solutions of bivalent cobalt, while the protein-bound group gives the reaction, appearing as a characteristic 'double wave', in ammoniacal solutions of both bivalent and trivalent cobalt[8].

The application of the first test has shown that there is no change in the level of free reduced glutathione in the homogenate for approximately 80 days when the results are expressed per unit of deoxyribonucleic acid (5×10^{-12} gm.). Then there occurs a rather sudden drop in the level of reduced glutathione which falls to only 20 per cent of the original in developed hepatoma and only 10 per cent in transplantable Novikoff's hepatoma of the rat (Table 1). The sudden drop in the level of reduced glutathione after 100 days seems to coincide with that critical period of carcinogenesis when the anaerobic glycolysis suddenly starts to increase[9].

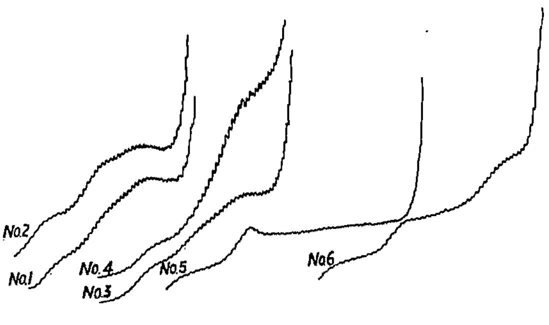

Fig. 1. Effect of the carcinogen 3′-methyl, 4-dimethyl aminoazobenzene (40 days) on free SH-groups in the supernatant of rat liver. (1) Control (basal diet) and (2) experimental, 0·2 ml. supernatant (dilution 1 : 10) added to 5 ml. Brdička's solution containing 0·1 *N* ammonium hydroxide, 0·1 *N* ammonium chloride and 5×10^{-4} *M* luteocobaltichloride. No polarographically detectable difference in sulphydryl content of undenatured soluble proteins.

(3) Control and (4) experimental, as for curves 1 and 2, but Brdička's solution contains bivalent cobalt ($CoCl_2.6H_2O$) instead of trivalent cobalt. Experimental sample shows increase of non-protein SH-groups.

(5) Control and (6) experimental. The effect in the experimental sample remains after deproteinization. Dilution by the deproteinizing agent is responsible for apparent decrease of catalytic reaction in comparison with curve 4. Sensitivity: 100 m.amp. for full deflexion

The second test was applied to the deproteinized (in an equal volume of 10 per cent sulphosalicylic acid) supernatant (1 hr. at 59,000*g*) after diluting the original homogenate to a 10 per cent suspension with sucrose. In this test a remarkable increase in the catalytic current with one single high maximum was evident in a few weeks after initiation of feeding with the carcinogenic azo-dye. This effect persisted during the whole period of carcinogenesis up to the development of gross tumours in the liver. Fig. 1 illustrates this effect in a sample prepared from liver about 40 days after the start of feeding with the carcinogen. The effect in the experimental sample disappeared if it was preincubated with 1×10^{-3} *M* iodoacetic acid for 30 min. at room temperature in slightly alkaline solution.

These polarographic observations indicate a striking change in the distribution of free SH-groups during liver carcinogenesis which may have important implications: an 'early' effect, which follows fixation of the carcinogen to protein and persists through the whole period of carcinogenesis, is manifest in the increase of sulphydryl groups; and a 'late' effect, which seems to coincide with the onset of malignant transformation and is manifest in a sudden decrease in free sulphydryl groups. Whether these effects belong to different SH-compounds or both are due to reduced glutathione in different states remains to be elucidated. It also remains to be shown whether changes in SH-levels occur in carcinogenic processes induced by other carcinogens outside the liver.

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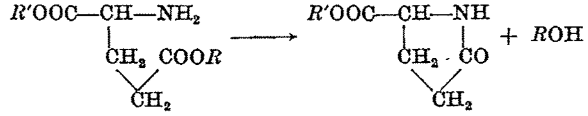
Carbon Dioxide Catalysis of the Formation of Pyroglutamic Acid

GLUTAMIC ACID and its esters and salts have a tendency to form α-pyrrolidone derivatives[1] by lactam formation :



(R,R' = H, Ca, Alkyl)

The cyclization can be brought about by heating. A strong catalytic effect of ammonia has been recorded[2].

Our experiments have revealed that carbon dioxide has a marked catalytic effect on the cyclization reaction. Dimethylglutamate is stable in dioxane at 25° C. in the absence of carbon dioxide for periods of several weeks. On saturation with carbon dioxide, however, fast cyclization occurs with a half-life of approximately 10 hr. The course of the reaction can be followed by potentiometric titration of the free amino-groups.

The reaction is of second order with respect to the amino-groups belonging to the uncyclized substance. If, however, an amine is added, which is more basic than the glutamic ester itself (for example, hexylamine), the reaction becomes of first order with respect to glutamic amine. The presence of weaker amines (for example, aniline) or tertiary amines does not change either the rate or the order of the reaction.

The order of reaction does not depend on carbon dioxide pressure, all second-order plots falling on straight lines. The dependence of the overall rate on the pressure of carbon dioxide is shown in Fig. 1. The values of k and n can be determined from the slope and intercept in the log–log plot. For dimethylglutamate at 25° C. in dioxane $n = 1{\cdot}01 \pm 0{\cdot}03$ and $k = 0{\cdot}63$ l. mole^{-1} atm.$^{-1}$ hr.$^{-1}$.

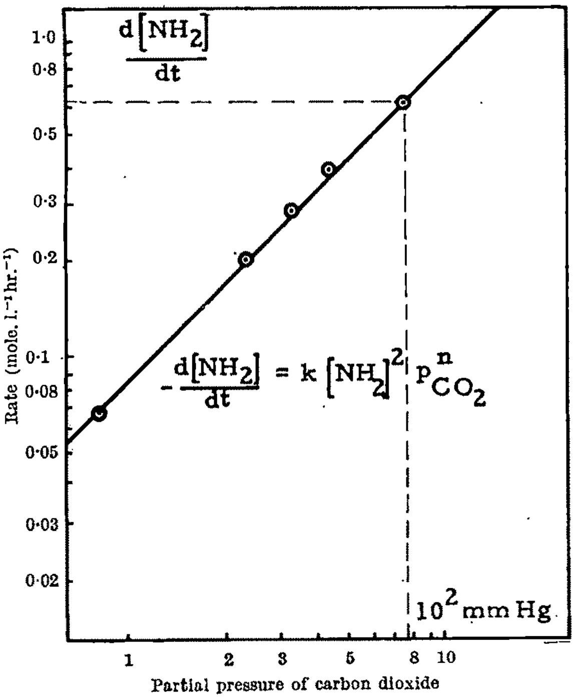


Fig. 1. The order with respect to carbon dioxide and the rate constant (k) can be determined from the plot of log(rate) vs. log(p_{CO_2}). For dimethylglutamate in dioxane at 25° C., $k = 0{\cdot}63$ l. mole^{-1} atm.$^{-1}$ hr.$^{-1}$; $n = 1{\cdot}01 \pm 0{\cdot}03$

On the basis of this evidence it can be concluded that carbon dioxide catalysed cyclization of the γ-esters of glutamic acid involves the formation of carbamates :

$$2R{-}NH_2 + CO_2 \longrightarrow R{-}NH{-}COONH_3{-}R$$

and that it is the carbamate salt which is the reactive species. (For a similar mechanism in condensations of α-amino-acids see ref. 3.) A weak base (aniline) will not be able to fix carbon dioxide.

In the series of glutamic diesters a marked influence of the nature of the γ-ester group is observed. The cyclization products of the diesters were all identified as the corresponding esters of pyroglutamic acid. The rate constants at 25° C. and 720 mm. mercury partial pressure of carbon dioxide are :

Dimethylglutamate	k = 0·600 mole.l.$^{-1}$hr.$^{-1}$
Diethylglutamate	0·280
Di-*n*-propylglutamate	0·262
Di-*iso*propylglutamate	0·038

These findings have an important bearing on the polymerization of the Leuchs anhydride of γ-esters of glutamic acid. Oligopeptides of γ-benzylglutamate in dioxane lose their amino end-groups rapidly in presence of carbon dioxide, and there is some evidence that the rate of cyclization increases with the molecular weight of the peptide. It is important to notice that during the polymerization of Leuchs anhydrides the solution is saturated with carbon dioxide, and therefore the occurrence of a termination is probable, mainly in the initial part of polymerization, when the rate of growth of the chains is low and the concentration of amino-groups is high[4]. The cyclization reaction, therefore, has an effect on the molecular-weight distribution of the resulting polymer, tending to increase the polydispersity.

Support for this work was provided by the Union Carbide Corporation.

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Isolation of the α_2-Globulin Pattern on Starch Gel

ZONE electrophoresis of serum proteins in starch gels was first described by Smithies[1], who employed a borate buffer system and silver electrodes. Poulik[2] described a discontinuous system using *tris* (trihydroxymethylamino-methane) and borate buffers for the separation of proteins. Two-dimensional electrophoresis on paper, and then on starch gel as used by Smithies and Poulik[3,4], revealed at least six molecular size-groups in the α_2-globulin group. A modification of this method is described, which utilizes the combination of haptoglobins with hæmoglobin to give a faintly coloured band as visual marker of the α_2-region and thus avoids staining. Commercially available starch is used as supporting medium, and provides a wide separation of the individual fractions.

The first electrophoresis was carried out on a strip of Whatman paper No. 3*MM*, 14 cm. wide, applying 0·1 ml. serum over 3 cm. Approximately 0·005 ml. of a hæmoglobin solution—about 5 gm. per cent—was then added to 0·2 ml. of the same serum, and 0·1 ml. of this serum was applied to the same paper 2 cm. distant. The buffer was veronal, 0·06 *M*, and the tank was that described by Flynn and de Mayo[4,5]. Using a current of 0·2 m.amp./cm. width, the length of the run was 11·5 cm. after 17 hr. The addition of the hæmoglobin solution made the identification of the α_2-region possible without staining, because the haptoglobins of the group combined with hæmoglobin and became faintly coloured. The excess hæmoglobin superimposed on the β-globulins and the edge nearest the anode defined the limit of the α_2-region. The marked and the stained strips are compared in Fig. 1.

The starch gel was prepared from Hopkin and Williams's soluble starch (analytical reagent grade) at a concentration of 12·5 gm./100 ml. in 0·01 *M tris* adjusted to *p*H 8·5 with saturated aqueous citric acid. 10 ml. of glycerol were added to 240 ml. of buffer. The gel was poured into glass trays, 20·5 cm. × 20·5 cm., and allowed to set in the refrigerator for 30 min. The electrode compartments contained each 250 ml. 0·3 *M* borate buffer, *p*H 8·6. The wet α_2-region of the paper strip was subdivided into four strips, each 5 mm. wide, which were pressed together and inserted in the cut of a 4-cm. razor blade at a distance of 7 cm. from the cathode end. Whole serum was inserted similarly, applying 0·02 ml. to a strip of cellulose acetate, 4 cm. × 5 mm. A small amount of *tris* buffer was applied to the surface of the strips and the excess blotted off. The bridges consisted of two sections of surgical lint, 21 cm. × 10 cm., moistened with borate buffer. The voltage was applied from a power-pack giving 305 V. on load. The current started at 1·7 m.amp./cm. width and finished after 2 hr. at 2·7 m.amp. The block became perceptibly warm and was cooled for 5 min. in the refrigerator and then cut and stained as usual. Three batches—Nos. 40054, 40055 and 44874—of analytical grade of starch were employed, giving closely comparable results. Fig. 2 shows a typical electrophoresis pattern for serum and the corresponding pattern for α_2-globulins.

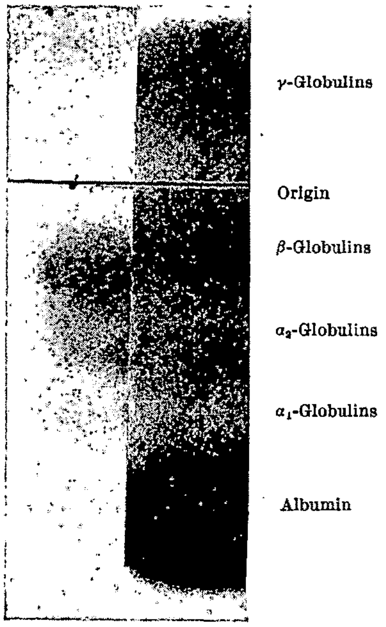

Fig. 1. Paper electrophoresis: left, positions of β- and α_2-globulins marked with hæmoglobin; right, stained with naphthalene black

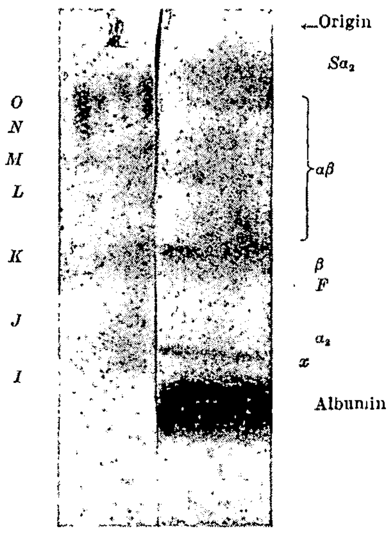

Fig. 2. Starch gel electrophoresis: left, fractions of α_2-globulins; right, whole serum. Legend as Smithies, refs. 1, 3. (*x* is an artefact)

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Substances in the Calf Alimentary Tract interfering in the Determination of Polyethylene Glycol

THE water-soluble polyethylene glycols of high molecular weight promise to be of great value as reference substances in the study of exchange processes in the alimentary canal. In particular, a mixture of such polymers with a molecular weight of about 4,000 appears to pass largely unchanged and unabsorbed through the alimentary tract in sheep, humans, hens, cows and calves[1,2]. Polyethylene glycol can readily be determined turbidimetrically, once interfering substances have been removed, after precipitation with trichloracetic acid solution containing barium chloride[2,3]. We found, in agreement with Hydén[3], that an initial treatment with barium hydroxide, zinc sulphate and barium chloride sufficed to remove interfering substances (mainly protein and sulphate) from milk and from calf rumen contents, urine and fæces extracts. The method failed, however, in two respects when it was applied to samples from fistulæ in the small intestines of milk-fed calves.

(1) The filtrates obtained from samples taken from the cæcal end of the small intestine after treatment with barium hydroxide/zinc sulphate/barium chloride contained a factor which inhibited the formation of the normal polyethylene glycol suspension on the addition of trichloracetic acid/barium chloride solution. Polyethylene glycol added to such filtrates was recovered to an extent of only 50 per cent or less. Nothing is known of the nature of the interfering substance, but it was removed on adding lead acetate to the sample made alkaline with barium hydroxide.

(2) Similar filtrates from samples obtained from fistulæ a few cm. below the junction of the abomasum and duodenum gave a strong turbidity with trichloracetic acid/barium chloride solution in the absence of polyethylene glycol. The effect was particularly marked in samples taken a few hours after feeding, and neutralization of acid in the samples with more barium hydroxide gave no improvement. The filtrate gave a pink reaction with the biuret test, and it seems probable that the interfering factor was degraded protein produced in the abomasum.

Of many metallic ion treatments tried, the only one which successfully precipitated this protein was that in which mercuric chloride was added to the sample, previously made alkaline with barium hydroxide, to give a final *p*H of about 9–10·5. At a higher final *p*H all the protein was not removed; at a lower *p*H (that is, in the presence of excess mercuric chloride) some of the polyethylene glycol was precipitated (Table 1). The mixture obtained by this procedure was difficult to filter. Moreover, the interfering factor in the contents of the cæcal end of the small intestine was not removed. Both these objections are overcome by the preliminary step in the following procedure.

Table 1

Mercuric chloride (2·7 per cent) added (ml.)	Final *p*H	Estimated polyethylene glycol in sample (p.p.m.)	
		1,000 p.p.m. polyethylene glycol added	No polyethylene glycol added
1·3	11·56	1,110	120
1·7	10·75	1,030	10
1·8	10·05	1,000	<10
2·0	9·30	1,010	<10
2·2	8·95	1,010	<10
2·6	8·60	850	<10

Sample from abomasal end of small intestine. Procedure as described in text except that different amounts of mercuric chloride were used.

The contents of the small intestine are centrifuged and 2 ml. of the supernatant fluid added to a small flask with 2 ml. water and 3 ml. of 0·3 *N* barium hydroxide. 1·5 ml. of 6·6 per cent lead acetate is added slowly and followed by 1·5 ml. of 5 per cent zinc sulphate. The mixture is filtered and 5 ml. of the slightly cloudy filtrate added to another flask with 1·5 ml. water and 1·5 ml. of 0·3 *N* barium hydroxide. To this is added, a drop at a time while shaking, 2 ml. of 2·7 per cent mercuric chloride to give a final *p*H of 9–10·5. (The concentration of the mercuric chloride solution may have to be modified slightly, depending upon the other reagents and the acidity of the samples.) The mixture is filtered, and an unknown mercuric compound which is otherwise slowly precipitated from solution is removed by the addition of one drop of 5 *N* ammonium hydroxide and a further filtration. Polyethylene glycol can be determined in the filtrate in the usual way[2]. The mean recovery of polyethylene glycol added to eleven samples from different parts of the small intestine was 101·4 per cent (standard deviation: ± 0·3 per cent).

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Effect of Thyroxin Administration on the Rate and Steric Course of Enzymatic Reduction of Steroids

A necessary step in the enzymatic inactivation of Δ^4-3-ketosteroids, for example hydrocortisone, is the reduction of ring *A* [1,2]. Evidence that this process may be accelerated in thyrotoxicosis in man has been presented by Levin[3] and Peterson[4]. Because of this, the influence of thyroxin administration on the enzymatic reactions involved in the reduction was studied.

50-gm. male Sprague–Dawley rats injected daily, intraperitoneally, with 0·5 μmol. of L-thyroxin were used in the following experiments. They were killed by decapitation; livers were excised and homogenized with 2 vol. of 0·25 *M* sucrose at 0° C. Liver homogenates from rats treated as few as three days with thyroxin showed an increased ability to reduce cortisone (Table 1, col. 2). Usually little or no reducing activity was detected in liver homogenates from control rats. However, when an excess of reduced triphosphopyridine nucleotide or a system generating it was added to this incubation mixture, the results in Table 1, col. 3 were obtained. This indicated that (*a*) the rate of steroid reduction was limited by reduced triphosphopyridine nucleotide in both rat liver homogenates, and (*b*) the difference in activity between the homogenates from the thyroxin-treated and control rat was abolished by reduced triphosphopyridine nucleotide, from which one could infer the greater availability of the nucleotide for this reduction in the treated animal.

When injections were continued for a minimum of 17 days, it was found, as shown in Table 1, cols. 4 and 5, that the difference in activity could no longer be abolished by adding an excess of reduced triphosphopyridine nucleotide, and although the activities of both preparations were greatly stimulated by the added nucleotide, the homogenate from the treated animal was still approximately twice as active as the control. When the livers were fractionated by differential centrifugation[5], the increase in activity in the thyroxin-treated animal was found in the micro-

Table 1. Rate of Reduction of the 4–5 Double Bond of Cortisone by Liver Homogenates
(mμmoles cortisone reduced/min./gm. liver)

	Treated 3 days		Treated 17 days	
	Without TPNH	With TPNH	Without TPNH	With TPNH
Control	7	198	10	233
Thyroxin-treated	34	207	43	449

Liver homogenates were incubated at 37° in air with cortisone, with and without a reduced triphosphopyridine nucleotide-generating system composed of excess triphosphopyridine nucleotide, isocitric acid, isocitric acid dehydrogenase and magnesium chloride. Aliquots were removed before incubation and at 5 min., extracted with dichloromethane, the optical density of which was determined at 240 μmol. The loss of absorbance at 5 min. is expressed as μmoles cortisone metabolized/min./gm. of liver.

Table 2. Rate of Reduction of the 4–5 Double Bond of Cortisone by Cell Fractions
(mμmoles cortisone reduced/min./gm. liver)

	Control	Treated with thyroxin for 70 days
Crude homogenate	121	415
Mitochondria	6	0
Microsomes	5	174
Soluble	93	90

Experiment performed as described in Table 1 in the presence of a reduced triphosphopyridine nucleotide-generating system. Mitochondria and microsomes were prepared by a modification of the method described by Hogeboom (ref. 5). Mitochondria were washed five times and microsomes twice with 0·25 *M* sucrose. The soluble fraction was the supernatant from centrifugation of crude homogenate at 120,000*g* for 90 min.

somal fraction alone (Table 2). This increase in activity was not accompanied by an increase in the number of microsomes (judged turbidimetrically) or microsomal nitrogen.

Paper chromatography[6] of the steroids resulting from the incubation of cortisone and reduced triphosphopyridine nucleotide with microsomes from treated and untreated animals demonstrated three blue tetrazolium-reducing compounds with the mobilities of 3α- and 3β-hydroxy-5α-tetrahydrocortisone and 5α-dihydrocortisone. The reduction of Δ^4-3-ketosteroids to 5α-dihydrosteroids by microsomes and reduced triphosphopyridine nucleotide has been described by Forchielli[7]. The reaction of cortisone and reduced triphosphopyridine nucleotide with the soluble fraction obtained from treated and untreated animals produced only one blue tetrazolium-reducing compound, 3α-hydroxy-5β-tetrahydrocortisone. This has previously been described as the product of cortisone reduction catalysed by soluble enzymes of the normal rat liver[3,4].

Thus there are two effects of thyroxin on the rate of cortisone reduction : an early increase in available reduced triphosphopyridine nucleotide, and, following prolonged treatment, an increase in the activity of a microsomal enzyme catalysing the reduction of the 4–5 double bond of ring *A*. This enhanced microsomal activity results in an increase in the production of the 5α isomer. Since the soluble enzyme producing the 5β-dihydrosteroid is not affected by this treatment, there would result an increase in the ratio of the 5α to 5β isomers. This is consistent with the findings of Bradlow *et al.*[8], who reported a shift in urinary metabolites of carbon-14 testosterone from the 5β to the 5α series following the administration of triiodothyronine to humans.

The effects described here with cortisone as a substrate have also been seen with other Δ^4-3-ketosteroids (hydrocortisone, deoxycorticosterone, Δ^4-androstene-3-17-dione, testosterone, corticosterone).

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Secretion of Androgens by the Adrenal Cortex of the Mouse

THE transitory inner cortical *X*-zone of the virgin female mouse first described and illustrated by Masui and Tamura[1] and later by Howard-Miller[2], Deanesly[3] and many others, regresses rapidly during the first pregnancy and only gradually in the unmated female. It is unaffected by ovariectomy. A similar zone disappears in the male mouse before maturity but persists or redevelops after immature or adult castration. In the normal male, therefore, endogenous androgens cause regression of the zone and in both the castrated male and the virgin female exogenous androgens have the same effect[4,5]. Only androgens among purified hormones do this, so it is generally agreed that male hormones must circulate in the pregnant mouse. Jones concludes[6], after a long series of investigations, that these androgens are derived from the ovaries under the stimulation of placental gonadotrophins. The present experiments show, however, that *X*-zone regression can be stimulated in the ovariectomized unmated female or in the castrated male by subcutaneous injections of adrenocorticotrophic hormone, indicating that androgens are produced by the adrenals themselves.

Eleven virgin mice ovariectomized at 20 gm. were injected either at once or a few days after the operation with Armour's 'Acthar', 4 units twice daily for 4, 5 or 10 days, and were killed on the following day, except for two mice which were killed 6 days later. Two other mice received 4 units once daily for 10 days. In these thirteen experimental animals the *X*-zone had disappeared or was in the final stages of regression in ten and in the other three it showed hyperæmia and stages characteristic of earlier degeneration. Three control ovariectomized mice had well-developed adrenal *X*-zones. Similar experiments in twelve normal virgin mice gave similar results ; in eleven the *X*-zone had regressed completely or was in the last stages of regression and in the other it had half degenerated. The reproductive organs in this group showed no indications of gonadotrophic stimulation. Out of seven normal controls the adrenal *X*-zone was intact in all except two, which showed very early stages of degeneration.

Male mice were castrated at 10 gm. and given adrenocorticotrophic hormone 4–6 weeks later when the *X*-zone was well developed, resembling the one in the virgin female. The results were similar, but rather larger or more effective doses of adrenocorticotrophic hormone were necessary for complete *X*-zone regression than in the females. Of the first seven mice receiving 5 units of adrenocorticotrophic hormone (Organon) in beeswax and oil daily for 5 days, or 8 units in gelatine daily for 5 days, only four showed partial regression of the *X*-zone. If injections of 'Acthar' (Armour) were continued for 9–10 days, however, the *X*-zone disappeared in seven of the eight mice, the remaining mouse having died on the fourth day, showing the cortical enlargement and hyperæmia which precede the degeneration of the *X*-zone. One other mouse received only 4 units daily of adrenocorticotrophic hormone (Organon) in beeswax and oil, and on the eleventh day, when it was killed, the adrenal was markedly stimulated. Not only had the *X*-zone regressed, but also in this and in four other injected mice the seminal vesicles and prostate showed tubular enlargement and glandular activity as compared with those of the castrate controls—a further indication of the presence of male hormone.

Androgens are excreted by the ovariectomized rabbit and by the pregnant ewe, monkey and cow[7]. In the monkey and cow there is evidence that they are derived from the adrenal cortex. It may be concluded that normal regression of the *X*-zone in the mouse is due to an increase in androgen secretion during pregnancy from the adrenal cortex itself such as has been found in other mammals, and is not caused by ovarian androgens, as maintained by Jones[6].

I am indebted to Dr. D. M. V. Parrott for advice on the administration of adrenocorticotrophic hormone.

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Calcium and Magnesium Content of Normal Human Blood Serum

THERE is some 20 per cent difference between the mean values reported, from statistically significant numbers, for calcium, and a wide range of difference for magnesium in normal human blood serum (Table 1). It would thus appear that some, at least, of the methods currently used for the determination of these two cations in serum yield erroneous values. Indeed, until the advent of metal indicators, all so-called clinical methods for determining both calcium and magnesium were open to question.

It would appear that the ashing of whole serum is a necessary step in assessing the value of any method for determining the total calcium or magnesium in it. The literature, however, is significantly wanting in this respect, perhaps because the recovery of the metals from dry ashing procedures in silica crucibles is difficult and uncertain, and the use of platinum is precluded as it reacts with the metal indicator 'Eriochrome black *T*'. When wet-ashing methods are used, the ubiquity of calcium and magnesium makes reagent blanks a major consideration, especially with micro-methods. Hence the importance of the observation of Middleton and Stuckey[5] that tissue organic matter can be destroyed in a flat-bottomed vessel on a hot plate at about 320° C. by repeated treatment with concentrated nitric acid which can readily be distilled free from metals.

With the method already described[6] for the micro-determination of calcium and magnesium, 0·25 ml. of serum is adequate for duplicate titrations of both metals. This amount, with 0·1 ml. of nitric acid, in a small 'volumetric' shaped 'Pyrex' flask with a flat (and level) bottom, diameter 3 cm., height 6 cm., stem 1 cm. in diameter and 3·5 cm. long, and capacity to the top of bulb about 8 ml., is gently evaporated to near dryness and then transferred to a hot plate at about 320° C. for 10–15 min. The flask is cooled, 0·1 ml. of nitric acid is again added, it is brought to near dryness and the flask is then transferred to the plate at 320° C. The ash may be white—indicating the complete destruction of the organic matter—at this stage but a third treatment is usual. To the dry ash is now added 2·5 ml. of 0·1 *N* nitric acid. The flask with contents is weighed, set on a hot plate to boil gently for about 10 min., reweighed, and the loss made up by addition of deionized water. From this test solution, 0·5-ml. portions are used for the determination of calcium with murexide as indicator, and 0·2-ml. portions for the determination of magnesium plus calcium with 'Eriochrome black *T*' as indicator.

Table 1. CALCIUM AND MAGNESIUM CONTENT OF NORMAL HUMAN BLOOD SERUM.
(mgm./100 ml. serum)

Reference	Method	No. of sera	Calcium: Mean	Calcium: Range	Magnesium: Mean	Magnesium: Range
1	Spectrographic	86	8·6	6·1–10·5	—	—
		103	—	—	1·90	1·21–2·54
2	Removal of calcium with oxalate and protein with trichloracetic acid. Colorimetry with 'Eriochrome black *T*'	24	—	—	2·10	1·75–2·50
3	Whole serum with murexide solution titrated with ethylenediamine tetra-acetic acid	710	9·7	8·9–10·5	—	—
3	Oxalate–permanganate	712	10·5	9·7–11·3	—	—
4	Flame spectrophotometric	22	10·8	—	—	—
4	Oxalate–permanganate	22	10·4	—	—	—
This work	Removal of protein by *p*H adjustment and heat (ref. 7) and colorimetry as described (ref. 6)	34	9·5	8·8–10·4	2·03	1·80–2·30

By this method calcium and magnesium added to serum have been precisely recovered, even in the presence of phosphate added up to 40 mgm./100 ml. serum.

The formation of complexes with the indicators by such trace metals in serum ash as copper, zinc, manganese and iron is considered to be negligible.

In Table 2 the analyses of the ash of thirteen sera from hospital patients, carried out as described above, are set alongside those obtained by the same analytical method from deproteinized serum filtrates prepared as previously described[7]. The close agreement of the two methods shows that suitably deproteinized serum filtrates yield true values for calcium and magnesium and renders the rather tedious ashing procedure unnecessary for routine purposes.

The oxalate–permanganate method commonly used in hospitals for the determination of calcium on 2-ml.

Table 2. CALCIUM AND MAGNESIUM DETERMINED ON SOLUTIONS OF THIRTEEN ASHED HOSPITAL SERA AND ON THEIR CORRESPONDING DEPROTEINIZED FILTRATES
(mgm./100 ml. serum)

	Calcium: Ash	Calcium: Filtrate	Magnesium: Ash	Magnesium: Filtrate
Mean	9·02	9·05	1·98	1·99
Range	7·9–10·0	8·0–9·9	1·80–2·25	1·80–2·20

serum samples gives values, on the present evidence, about 10 per cent too high. Nine sera from hospital patients were examined by both methods with the following results: oxalate method, mean 10·3, range 9·9–10·9 mgm./100 ml.; murexide method, mean 9·2, range 8·8–9·6 mgm./100 ml.

I am indebted to Dr. A. Preston, Oxford Regional Transfusion Service, for the normal bloods reported in Table 1. This work is part of a programme in the development of methods for the study of the blood-cerebrospinal fluid barrier in association with Dr. H. V. Smith, May reader in medicine in the University of Oxford, and is made possible by a grant from the Nuffield Foundation.

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Tolerance of Skin Homografts related to Fatal Disease in Separated Rat Parabionts

Homotransplantation of viable tissue in adult individuals is possible only between identical or monozygotic twins. Successful homografting between dizygotic calves is due to anastomoses of placental vessels[1]. However, tolerance to homografts may be artificially induced[2] if animals are exposed to foreign tissue antigens during fœtal life. The upper limit of the period of tolerant response varies in different species but never extends far beyond birth[3]. In rats[4] tolerance may be induced as late as the second week of life.

In all these cases some form of parabiosis had existed and played the essential part in conferring tolerance. In an attempt to extend still further the 'adaptive' period it seemed justified to use parabiosis as a procedure of choice and see whether tolerance could be conferred at a more advanced stage of development, perhaps even in adult animals.

122 albino rats of both sexes, weighing 80–180 gm. (age, 5–13 weeks) and belonging to two unrelated random-bred strains, Y and W, were used; donor and recipient always belonged to a different strain and were of the same weight and sex. 38 animals were tested for compatibility with free full-thickness skin grafts; no graft survived beyond the twelfth day (mean survival time $W \rightarrow Y$, $8\cdot1 \pm 0\cdot4$ days; $Y \rightarrow W$, $10\cdot2 \pm 0\cdot4$ days; $0\cdot001 < P < 0\cdot01$). 84 animals were put in parabiotic union[5], making a total of 42 pairs; a tubed pedicle was formed from the dorsal lip of the skin wound in the donor and its distal free end sutured into a defect on the back of the recipient. Ether anæsthesia combined with urethane (100 mgm. per 100 gm. body-weight) was used throughout. The animals were separated on the fifth post-operative day; the tubed pedicle was ligatured and cut as near the graft as possible.

Results are presented in Table 1. Twenty-five separated hosts (59·5 per cent) completely destroyed their grafts by the tenth post-operative day. Eleven recipients (26·2 per cent) carrying viable grafts appeared at first to be healthy; suddenly, between the eighth and the twenty-fifth post-operative day, the animals became ill and died from within a few hours to a couple of days from the onset of the disease. The illness sometimes followed a more protracted course, the animal dying as late as the forty-third post-operative day. At time of death, the majority of grafts were fully preserved, showing good growth of hair. In some cases there was an initial necrosis of superficial epidermal layers, but that was as far as the immune reaction of the host could go except in two cases where grafts were considerably reduced in size. Regeneration took place only from graft. The best preserved part of the graft was always that farthest from the remnant of the tubéd pedicle.

Table 1. Fate of Grafts, Number of Recipients (with percentages in brackets)

Graft destroyed by the tenth day	Graft viable at time of host's death	Prolonged survival of graft	Alive with viable graft	Total
25 (59·5)	11 (26·2)	5 (11·9)	1 (2·4)	42 (100)

These 11 hosts are shown in Table 2. The cause of death was severe anæmia, pulmonary œdema and sometimes inanition. Post-mortem examination revealed atrophy of lymph glands with almost complete disappearance of thymus. The spleen and adrenals were usually enlarged. *Bartonella* parasites were not found. The incidence of disease was evenly distributed between the two strains and sexes. Five more hosts (11·9 per cent) recovered and destroyed their grafts between the fifteenth and the twentieth post-operative day. One host (2·4 per cent), a female weighing 170 gm., also recovered and is still in a good condition 72 days after the operation, carrying a partly preserved graft. This animal was challenged with a graft from the third strain on the eighteenth post-operative day. This it destroyed completely 13 days later. This very limited trial shows that a graft could be made tolerant of its host too, and that tolerance in these cases might be strain-specific.

The disease described herein strikingly resembles and is probably identical with the so-called 'parabiotic disease'[5]. The same might be true of conditions recently described in mice[6] and chicks[7]. Parabiotic disease is a very common occurrence in permanent parabiosis between genetically unrelated partners, and in our experience appears in one of the parabionts between the seventh and thirteenth post-operative days. The animal usually dies in a few days but may recover if separated from its partner sufficiently early (unpublished work). The graft and its host could be considered as two distinct animals and, though

Table 2. Incidence of Disease as related to Sex, Weight and Strain Combination; Onset of Disease and Survival Times of Tolerant Hosts*

Sex	Initial weight (gm.)	Strain combination	Onset of disease (days after operation)	Died (days after operation)	Condition of graft at time of death†
♂	80	$W \rightarrow Y$	11	13	f.p.
♂	80	$Y \rightarrow W$	12	13	p.p.
♀	90	$Y \rightarrow W$	10	10	w.p.
♂	100	$Y \rightarrow W$	9	11	w.p.
♀	100	$W \rightarrow Y$	15	19	w.p.
♀	110	$Y \rightarrow W$	17	17	f.p.
♂	120	$W \rightarrow Y$	13	17	w.p.
♀	130	$W \rightarrow Y$	9	16	f.p.
♀	145	$Y \rightarrow W$	25	43	p.p.
♂	160	$Y \rightarrow W$	8	10	f.p.
♂	160	$W \rightarrow Y$	16	31	f.p.

* Data refer to eleven recipients from Table 1, col. 2.

† f.p., fully preserved graft; w.p., well preserved graft; p.p., partly preserved graft.

tolerated, the graft always remains an intruder. It is not surprising, therefore, that the graft and its host could behave as true parabionts. During parabiotic union, the graft connected with donor via pedicle could be conditioned to produce a much greater quantity of antibodies against its host than a free graft could. However, the graft may not be the only source of antibodies. Adult blood cells can survive and perhaps even multiply in embryos and newly born animals[6,7]. It is not impossible that some of the adult cells, exchanged in enormous numbers as soon as cross-circulation is established on the fourth day of parabiotic union, may also survive and form antibodies against their host.

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Effect of Oxy-chlororaphin on the Growth *in vitro* of *Streptomyces* Species and Some Pathogenic Fungi

During the course of other investigations, oxy-chlororaphin was found to inhibit strongly the growth of *Streptomyces* sp. 441. Chlororaphin (melting point 225° C. in nitrogen) was separated directly by centrifuging a five-day-old submerged culture of *Pseudomonas aeruginosa* containing glycerol (Sierra, G., and Veringa, H. A., unpublished work). Yields as great as 0·53 gm./l. were obtained (considerably greater than the yield of 5–16 mgm./l. obtained from a 14-day-old glucose culture at 28° C. by Birkofer[1]). Crystalline oxy-chlororaphin was obtained by dissolving chlororaphin in acetone (discarding the insoluble fraction). After cooling in contact with the air, the solution yielded crystals of oxy-chlororaphin. Several recrystallizations in acetone were necessary to obtain the pure compound (melting point 242° C.).

The activity tests were made by the usual method. Oxy-chlororaphin was incorporated into suitable agar media in an appropriate range of graded concentrations. The medium used was Sabouraud's glucose-agar, consisting of 0·5 per cent glucose, 2 per cent agar and 1·5 per cent 'Bacto-peptone' (Difco), the *p*H being adjusted to 5·6–5·8. *Streptomyces* cultures were incubated at 25° C. and cultures of pathogenic fungi at 37° C.

Manometric experiments show that a concentration of oxi-chlororaphin (333 parts per million) much higher than that necessary to inhibit completely the growth of *Candida albicans* in Sabouraud's glucose-agar medium does not affect the rate of uptake of oxygen from Sabouraud glucose by washed suspensions of this fungus. Oxy-chlororaphin (333 parts per million) does not affect the auto-respiration of *Candida albicans* in phosphate buffer (*p*H 6·4).

Table 1. EFFECT OF THE OXY-CHLORORAPHIN ON THE GROWTH OF SOME PATHOGENIC FUNGI AND *Actinomycetes*
The fungi were obtained from the Centraalbureau voor Schimmelcultures, Baarn, Holland; the *Actinomycetes* were from local stock

Cultures tested	Concentration of oxy-chlororaphin giving inhibition (parts/million)	
	Complete	Partial
Trichophyton mentagrophytes	12·5	6·3
Epidermophyton floccosum	25·0	12·5
Candida albicans	50·0	12·5
Microsporum audouini	25·0	12·5
Blastomyces dermatitidis	25·0	12·5
Streptomyces 404	25·0	6·3
Streptomyces 411	12·5	6·3
Estreptomyces 421	25·0	6·3
Streptomyces A. 425	25·0	6·3

No ill effects were observed in mice (weighing 20 gm.) injected intraperitoneally with 10 mgm. oxy-chlororaphin suspended in olive oil.

The action of oxy-chlororaphin certainly cannot be that of an antiseptic, in that it does not act as a general protoplasmic poison interfering with the respiration. As its action is more fungistatic than fungicidal, we may assume that it has some antagonistic action by which growth is prevented. Studies are under way to elucidate further the action of this compound *in vivo*.

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---

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A Strain of *Acetobacter aceti* giving a Positive Cellulose Reaction

A strain of *Acetobacter aceti* was isolated with many other acetic acid bacteria from ciders. It was identified by the use of Frateur's tests[1], and showed a positive cellulose reaction in addition to the usual characteristics of *A. aceti*, namely, catalase production, growth in Hoyer's medium, production of dihydroxyacetone from glycerol and gluconic acid from glucose. After staining the growth with iodine, and applying sulphuric acid, a blue colour developed. This reaction occurred slowly, and within 1–2 hr. the preparation appeared green. Microscopic examination revealed the presence of a non-cellular material which was blue in colour, intermingled with bacterial cells stained yellow by the iodine. The colour gradually intensified during the ensuing 24 hr. until the whole preparation then appeared blue.

The appearance of this organism in culture was quite unlike that of a typical cellulose producer, such as *A. xylinum*. It did not produce a cartilaginous pellicle in liquid media nor was the growth coherent on solid media, although it could be pulled into a short slimy string when touched with an inoculating needle. Further, the strain of *A. aceti* was actively motile and has been shown to possess peritrichous flagella (J. L. Shimwell, private communication).

There is thus a considerable difference between the cultural characteristics of this particular strain of *A. aceti* and of a typical cellulose producing *Acetobacter* species. In fact, the only characteristic which suggests the presence of cellulose in this culture of

A. aceti is the blue colour given with iodine and sulphuric acid. This suggests that the iodine–sulphuric acid test may not be specific for cellulose, which is not surprising since this appears to be a traditional and empirical test the mechanism of which is not fully understood. Alternatively, it may be that the amount of cellulose produced by this particular strain of *A. aceti* is insufficient to yield a tough leathery growth. The possibility that this organism may not produce true cellulose does not, however, affect its unusual taxonomic position: the only chemical criterion used by Frateur for cellulose production is the ability of a culture to produce a blue colour in the presence of iodine and strong sulphuric acid. This would include all true cellulosic organisms and any which produce substances giving a similar colour reaction.

As Shimwell[2] has already shown, the *Acetobacter* proper (excluding Frateur's *Suboxydans* group) are particularly prone to mutation or variation, one species easily changing to another by the loss or gain of certain biochemical activities. Shimwell[3] has suggested, on the basis of these findings, that it should be possible to find organisms with combinations of characteristics additional to the species listed by Frateur[1]. This has already happened since both Dr. Shimwell[3] and I (unpublished work) have found such organisms in vinegar brewing materials and ciders respectively. The significance of this strain of *A. aceti* is that it represents one end of the mutational range with *A. paradoxum* at the other, the former having all Frateur's characteristics positive and the latter all negative. It would, therefore, only appear to be a matter of time before all the 32 'species' postulated by Shimwell[3] are discovered.

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Utilization of Thiocyanate by *Thiobacillus thioparus* and *T. thiocyanoxidans*

Two years ago we began to study whether *Thiobacillus thioparus* and *T. denitrificans* could break down thiocyanate oxidatively in the same way as *T. thiocyanoxidans*; it was immediately apparent that the former did, but since initial results suggested that the first and last of these organisms might nevertheless be separate species we decided not to publish our results at that time. All strains of *T. denitrificans* received were contaminated and since it has been our practice to work from single-cell culture we abandoned temporarily the study of *T. denitrificans*.

De Kruyff, van der Walt and Schwartz[1] have shown the capacity not only of *T. thioparus* but also of *T. denitrificans* to break down thiocyanates both aerobically and anaerobically in the presence of nitrate. They suggest that *T. thioparus* and *T. thiocyanoxidans* are one and the same organism; and with the present cultures this seems probable. The *T. thiocyanoxidans* which they studied is identical with the one we are now using, but it is not our original strain and there have been metabolic differences in the strains we have isolated from time to time. We have always accepted the view of Baalsrud[2] that the different *Thiobacilli* may perhaps represent a similar group of organisms rather than distinct species.

In the present work *T. thioparus* and *T. thiocyanoxidans* were compared for their ability to utilize both thiocyanate and thiosulphate for growth. They are grown at 30° C. on thiosulphate or thiocyanate media prepared as follows. Thiosulphate medium: 1·0 gm. sodium thiosulphate ($Na_2S_2O_3$ $5H_2O$), 0·35 gm. potassium dihydrogen phosphate, 0·14 gm. potassium hydroxide, 0·01 gm. ammonium chloride, distilled water to 100 ml. Thiocyanate medium: 0·025 gm. potassium thiocyanate, 0·35 gm. potassium dihydrogen phosphate, 0·14 gm. potassium hydroxide, 0·01 gm. ammonium chloride, distilled water to 100 ml.

After sterilizing at 15 lb./in.^{2} for 15 min. and cooling, 1·0 ml. of each of two cool, sterile salt solutions *B* and *C* were added: (*B*), 1·0 gm. magnesium sulphate ($MgSO_4.7H_2O$), 0·2 gm. anhydrous ferric chloride, 0·2 gm. manganese sulphate ($MnSO_4.4H_2O$), 3 ml. concentrated hydrochloric acid, distilled water to 100 ml. (*C*), 1 per cent calcium chloride solution. Viable cell counts were made by direct plating on thiosulphate media set with agar and by the technique of serial dilution which was slightly modified from that used in "Bacteriological Examination of Water Supplies"[3]. Thus an estimate could be made of the most probable number of cells present in a culture of each medium. To do this, five series of tenfold dilutions (10^{-3}–10^{-9}) of cultures of each organism in both types of medium were used. In preliminary experiments the values for cell population obtained from the tables of most probable number derived from the paper on "Bacteriological Examination of Water" were compared with those obtained from direct plate counts. Values so obtained were identical within the limits of error for the method employed. Results showed the infectivity of both organisms for thiocyanate and thiosulphate to be equivalent.

Organism	Substrate	Most probable number of cells/ml.
T. thioparus	Thiosulphate	$5 \cdot 3 \times 10^6$
T. thioparus	Thiocyanate	$2 \cdot 0 \times 10^6$
T. thiocyanoxidans	Thiosulphate	$5 \cdot 2 \times 10^6$
T. thiocyanoxidans	Thiocyanate	$8 \cdot 3 \times 10^6$

These results obviously suggested that *T. thioparus* had a similar or identical capacity with *T. thiocyanoxidans* for growing on thiocyanate.

As a further check on this similarity or identity of metabolic properties, several cultures of both organisms which utilized thiocyanate were back-inoculated in serial dilution into thiocyanate medium. The dilutions were 1/30, 1/900, 1/27,000, 1/810,000, etc. In two series *T. thioparus* in 1/30 dilution of the culture grew and utilized thiocyanate in these further cultures upon thiocyanate while another failed completely; whereas cultures of *T. thiocyanoxidans* could be diluted to 1/27,000 or 1/810,000 and continue to raise fresh populations of cells utilizing thiocyanate. These results disturbed the provisional conclusion that both organisms were in fact identical, but further studies were made using a modified technique. Serial dilutions were made into 5 ml. of medium (instead of 3 ml.) and incubated for 10 days, and since both organisms grow in thiosulphate these cultures were back-inoculated into both thiosulphate and

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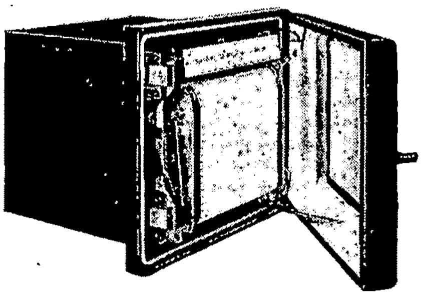

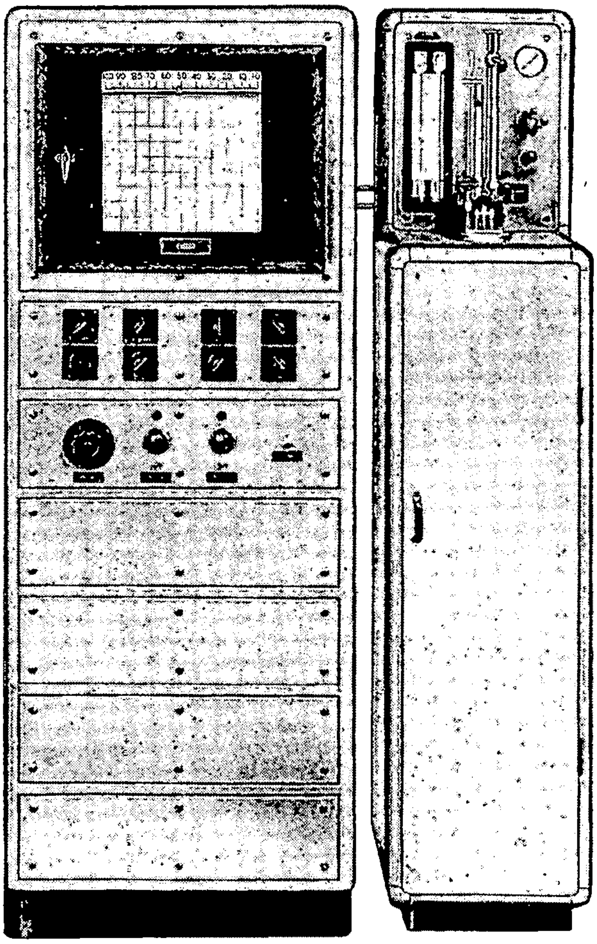

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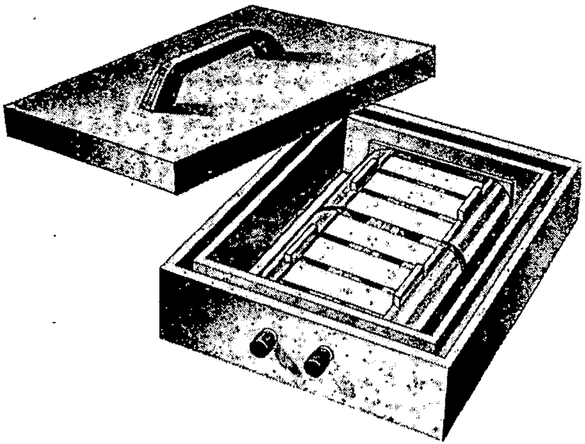

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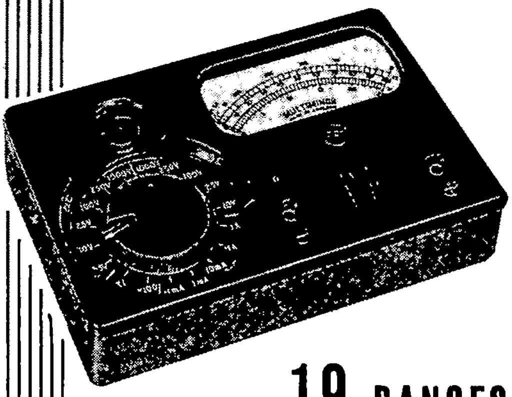

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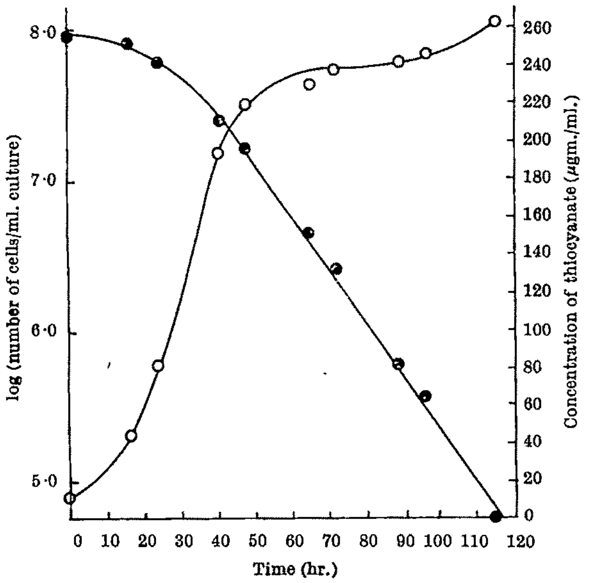

Fig. 1. Comparison of the growth of *Thiobacillus thiocyanoxidans* and its utilization of thiocyanate: ●, thiocyanate concentration (μgm./ml.); ○, log (number of cells per ml. of culture)

thiocyanate. The results were completely identical; growth occurred in thiosulphate medium throughout the whole range of dilution (1/30–1/24,300,000) and on thiocyanate medium down to a dilution of 1/810,000. Thus the identity of the present strain of *T. thiocyanoxidans* with *T. thioparus* as far as utilization of thiocyanate is concerned cannot be doubted—a result in conformity with the fuller findings of De Kruyff *et al.*

Fig. 1 represents the growth of viable cells of *T. thiocyanoxidans* with time, when the organism is grown at 30° C. in thiocyanate medium; the concurrent rate of disappearance of thiocyanate is also recorded. The viable cell population does not increase much after 48 hr. when approximately 20 per cent of the substrate has disappeared.

It should be mentioned, however, that cell autolysis seems to be rapid with this organism and there is abundant liberation of amino-acids and growth factors into the medium (including, Dr. E. Holdsworth tells us, some vitamin B_{12}) and thus many heterotrophs can grow in the supernatants which remain after the culture has apparently become sterile. We mention this fact since we do not accept the view of some distinguished workers that mass cultures of *T. thioparus* and *T. denitrificans* can be grown without careful sterilization and the resulting cells used for manometric and other studies, at least if the metabolism of these organisms are as close in metabolic properties to *T. thiocyanoxidans* as they appear to be.

Manometric experiments on the oxidation of various organic substrates by *T. thiocyanoxidans* have been carried out. Cells grown on thiosulphate medium show very little oxidation of formate or succinate, whereas cells grown on thiocyanate medium show a marked increase in the ability to oxidize both these substrates, especially in the case of formate. It has been observed that in cases where the cell suspension has a very high endogenous respiration, other substrates such as pyruvate have been oxidized. We have obtained colorimetric evidence which suggests that small amounts of formate may appear in cultures of *T. thiocyanoxidans* when growing upon thiocyanate.

We are grateful to De Kruyff *et al.* for directing our attention to the classical work of Beijerinck[4].

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The Pennatularian Genus *Umbellula*

The examination of a numerically large collection of two species of *Umbellula* from the Swedish Deep-Sea Expedition[1] implied that many of the specific criteria hitherto employed would have to be dropped. Later investigation of an interesting series of antarctic and subantarctic specimens from the *Discovery* collections, together with a revision of the collections of *Umbellula* kept in the British Museum, has confirmed this assumption.

The species of *Umbellula* vary rather extensively in external aspect according to age and development and evidently also under different ecological conditions and more or less fortuitous contractions. In the first case, however, there are two characters which by their combinations, so to say, divide the genus into four groups. Hickson[2], in accord with Kükenthal[3], emphasized the importance of the presence or absence of spicules as *fundamentum divisionis*; but in his last paper Hickson[4] discarded Kükenthal's other fundamental character, namely, a square or a round axis. Both authors seem to have overlooked the connexions between degree of calcification, finer structure of the inner parts and its relation to the anatomy of the cœnosarcal layers, and the external aspect of the axis.

The structure of the spicules, too, is so characteristic that we can base two separate species on them alone: *U. durissima* has rod-shaped or feebly fusiform spicules, some of them with feebly knobbed ends; *E. thomsonii* has rod- or needle-shaped, three-flanged or -ridged spicules. The difference between the two species is further emphasized by the axis, which in *durissima* is round and almost devoid of carbonate of lime, while in *thomsonii*, on the other hand, it is quadrangular and strongly calcified.

The other and larger group of the genus is devoid of spicules. Here the axis is round in two species and all but completely devoid of carbonate of lime and extremely flexible. But the polyp clusters are distinctly different. *U. huxleyi* has rather small autozooids concentrated in a packed pompom at the end of the rachis, whereas *U. spicata* has its autozooids irregularly spread over an exceptionally long, distal, swollen part of the rachis as a long tassel.

The last two (or possibly three) species of the genus again have quadrangular axes but these are heavily encrusted with carbonate of lime. *U. pellucida* has small autozooids packed in a pompon terminally on the rachis; the entire specimens evidently do not exceed 35 cm. in total length, and their axes are very thin and brittle as compared with all the other species. *U. lindahli* is much more robust, and in most examples its axis is remarkably flexible, despite its rather strong calcification. Fully grown specimens of this species are seldom less than 40 cm. long and have large autozooids, which, especially in colder waters, are placed in great numbers in more open tassels.

The six species mentioned are the only ones which are sufficiently described at present. Although the distribution of *U. encrinus* indicates that it is an arctic species, its structure suggests that it is only an extreme, ecological form of the cosmopolitan *U. lindahli*; this question needs further examination. A full report on the collection will appear in the "Discovery" Reports.

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June 23.

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Effect of Metal Ions on the Development of Wheat Stem Rust

DURING a study of the effect of benzimidazole, dimethylbenzimidazole, glucose and metal ions on the development of rust in detached leaves, certain metal ions have been noted to be extremely effective in the prevention of rust development in detached wheat leaves of both resistant and susceptible varieties.

Wheat seedlings at the two-leaf stage were inoculated with urediospores of *Puccinia graminis tritici* and incubated for 24 hr. in a moist chamber. At the end of incubation, the leaves were excised and floated on various solutions of metal ions in Petri plates. The development of rust was noted on the ninth day after excision of the leaves. Results of the effect of various metal ions on rust development in detached Khapli leaves are given in Table 1. Khapli leaves, normally resistant to race 15*B*–1, became susceptible after detachment when floated on water. From the results, it is evident that the rust development in these leaves is markedly checked by nickel ions even with a concentration as low as 0·5 p.p.m. Cobalt, molybdenum, copper, manganese and iron have no effect on rust development. Cobalt induces chlorosis in the leaves with concentrations of 2–4 p.p.m., and any concentration greater than this has been found to be toxic to the excised leaves. Zinc also produces chlorosis, but to a lesser extent, and it is not toxic at higher concentrations (10 p.p.m.). Zinc shows no effect on rust development at the lower concentrations and only slightly at higher ones, but results with zinc varied considerably. On the other hand, nickel yielded consistent results and did not induce chlorosis in the leaves with any of the concentrations tested.

Table 2. EFFECT OF NICKEL AND COBALT IONS ON THE DEVELOPMENT OF *Puccinia graminis tritici*, RACE 15*B*-1, ON DETACHED LEAVES OF LITTLE CLUB AND MARQUIS. OBSERVATIONS WERE MADE ON THE NINTH DAY AFTER EXCISION OF LEAVES

Variety	Rust development						
	Cobalt (p.p.m.)			Nickel (p.p.m.)			
	0	2	4	0	2	3	4
Little Club	++++	++++	++++	++++	+*	+	nil
Marquis	++++	++++	++++	++++	nil	nil	nil

* +, The type of rust reaction of attached resistant Khapli leaves.

Studies on the effect of metal ions on the rust development in detached leaves of susceptible varieties (Little Club and Marquis) were made only with cobalt and nickel. Results are given in Table 2. Cobalt shows no inhibition of rust development; on the other hand, nickel is very effective in the prevention of rust development in the detached leaves of susceptible varieties. With these varieties, a slightly higher concentration of nickel is necessary in order to obtain the same degree of inhibition as that found on Khapli leaves.

The effect of these metals on the inhibition of rust development in detached leaves does not correspond to their effect on germination and growth of urediospores of *P. graminis tritici*. For example, in descending order of effectiveness at 4 p.p.m., nickel, iron, zinc and copper inhibit both the germination and growth, cobalt inhibits growth only, having no effect on germination, whereas manganese and molybdenum have no apparent effect on either phenomena.

Sempio[1] had also shown that infection of *Puccinia triticina* was greatly reduced by adding nickel (*M*/7500) to the nutrient solution. Because of the results reported here it would be unwise to state categorically that nickel acts as a fungicide *per se*. Its effects on the host may be equally important and we have found that it has the effect of slowing down both the synthesis and breakdown of chlorophyll in uninfected detached etiolated and green leaves.

Table 1. EFFECT OF VARIOUS METAL IONS ON THE DEVELOPMENT OF *Puccinia graminis tritici*, RACE 15*B*-1, IN DETACHED KHAPLI LEAVES OBSERVATIONS WERE MADE ON THE NINTH DAY AFTER EXCISION OF LEAVES

Metal ion	Rust development								
	Concentration of metal ions (p.p.m.)								
	0	0·1	0·25	0·5	1·0	2·0	3·0	4·0	5·0
Ni^{++}	++++	+++	+	nil	nil	nil	nil	nil	nil
Zn^{++}*	++++	++++	–	++++	–	++++	–	+++	++
Co^{++}	++++	++++	–	++++	–	++++	++++	++++	toxic
Mo^{++}	++++	–	–	–	++++	–	–	++++	++++
Cu^{++}	++++	–	–	++++	–	–	–	–	++++
Mn^{++}	++++	–	–	++++	–	–	–	–	++++
Fe^{++}†	++++	–	–	–	–	++++	–	++++	++++

Key: nil, the site of rust infection appears as pin-point light-coloured spot; no further development. +, the original type of rust reaction–rust development is greatly delayed. + +, rust development is slightly checked; pustules are developed. + + +, rust development is not delayed; pustules are well developed. + + + +, rust development is not delayed; pustules are very well developed; sporulation is prolific.

* With 10 p.p.m. rust development gave +. † No effect was observed even with 10 p.p.m. solution.

Further studies are in progress to determine its site of action.

This work was conducted under Extra Mural Research Grant No. 14 of the Canada Department of Agriculture.

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Photoperiodic Induction of Flowering in Black-Currant

During the course of a detailed morphological investigation of flower-initiation in black-currant (*Ribes nigrum*) it was observed that under field conditions flower primordia are normally initiated in the axillary buds following the cessation of active extension growth of the shoot. This observation suggested that possibly flower initiation depends on the cessation of extension-growth and that treatments which bring about the latter might also induce flowering. It is known that this species grows actively under long-days but rapidly becomes dormant under short-days[1], and the following experiments were therefore carried out to test whether short-day treatment promotes flower-initiation.

Plants of the variety Baldwin raised from hardwood cuttings were allowed to grow under natural long-day conditions until they had attained a height of about 50 cm. They were then selected for uniformity and divided into three groups which were exposed to the following photoperiodic conditions, respectively: (1) 8-hr. photoperiods (29 plants); (2) 18-hr. photoperiods (19 plants); and (3) natural day-length conditions (10 plants). The treatments were commenced on June 21 and within 2–3 weeks the plants under short-day conditions were observed to have ceased extension growth. On July 29 (after 5 weeks treatment), 14 of these short-day plants were transferred back to long-days, under which conditions the axillary buds expanded in 2–3 weeks, and a high proportion of the axillaries in the upper part of the shoots produced flowers which set fruit in September. The plants maintained under long-day throughout continued active extension-growth until the experiment was terminated on September 12. At this date many of the axillary buds had elongated into short shoots which were entirely vegetative. The plants maintained under natural day-length conditions ceased extension-growth at the beginning of August and were afterwards found to have initiated flowers in the normal way.

Further experiments with plants decapitated before treatment (as part of another investigation) have confirmed these results and have indicated that a period of exposure to 16 short-days is sufficient to induce flowering, provided that fully expanded leaves are present on the plants. This latter result is directly comparable with the conditions necessary for photoperiodic induction of flowering in herbaceous plants and suggests that short-day treatment may have a direct effect on flower-initiation in black-currant, independently of any effect on extension-growth. This possibility is being further investigated.

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June 3.

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Effect of Number of Sprouts per Set on Yield and Grading of Main-Crop Potatoes

It is well known that the number of stems formed by a potato plant profoundly affects the size and number of tubers produced[1,2], and that some varieties tend to produce many stems and thus a high proportion of small unsaleable tubers[3]. If sprouted seed of such varieties with only one or two sprouts per set are planted, the resulting crop contains a high proportion of ware (table potatoes)[4].

In 1957 the effect of sprouted seed tubers on stem and tuber production was investigated in respect of four maincrop varieties (King Edward, Majestic, M.A.N.I. Seedling 480/51 and Ulster Supreme) in two seed sizes (mean weights 44 gm. (1½ oz.) and 80 gm. (2⅚ oz.)). Three sprout treatments were used: (*a*) all but one sprout removed; (*b*) all but three sprouts removed; (*c*) multiple sprouts as grown. Spacing was standardized at 36 in. apart each way. The plants were lifted by hand and recorded individually (Tables 1 and 2).

Table 1. MEAN NUMBER OF MAIN STEMS AND TUBERS PER PLANT

Variety	Seed size	Mean No. of main stems per plant			Mean No. of tubers per plant		
		a	*b*	*c*	*a*	*b*	*c*
Majestic	*M*	1·0	2·2	2·5	11·0	14·5	17·3
Ulster Supreme	*M*	1·0	2·7	3·7	11·0	17·0	19·4
King Edward	*S*	1·0	2·7	2·9	12·3	19·0	23·4
King Edward	*L*	1·0	3·0	4·6	19·8	23·7	32·2
King Edward	*M*	1·0	2·8	3·7	16·1	21·3	27·8
M.A.N.I. 480/51	*M*	1·0	2·7	9·5	20·5	22·9	45·7

S, Small seed; *L*, large seed; *M*, mean of small and large seed.

Table 2. MEAN NUMBER OF TUBERS PER PLANT IN EACH GRADE IN TREATMENTS *a* and *c*, SEED SIZE AVERAGED

Variety	Treatment	Grade			
		1	2	3	4
Majestic	*a*	2·9	3·5	2·1	2·5
Majestic	*c*	1·5	5·5	5·3	5 0
Ulster Supreme	*a*	5·5	3·2	1·0	1·3
Ulster Supreme	*c*	2·9	7·7	5·7	3·1
King Edward	*a*	1·7	4·8	5·2	4·4
King Edward	*c*	0·7	3·5	10·4	13·2
M.A.N.I. 480/51	*a*	2·1	6·1	5·9	6·4
M.A.N.I. 480/51	*c*	0·3	4·4	11·5	29·5

Grades 1, 342 gm. (12 oz.) and greater outsize; 2, 172–341 gm. (6–12 oz.), large ware; 3, 71–171 gm. (2½–6 oz.), small ware; 4, 2–70 gm., seed and chats.

There was a wide variation in behaviour between varieties in the number of stems and tubers formed[5], and their grading. At one extreme, M.A.N.I. 480/51 formed too many stems and tubers on treatment *c* (multiple sprouts) for satisfactory ware production, yielding a mean of 9·5 stems and 45·7 tubers per plant. Up to 17 stems and 69 tubers were recorded on a single plant, such plants producing little marketable ware. On treatment *a* (single sprouts) these were reduced to 1·0 and 20·5 respectively, when this variety appeared to be a useful cropper of large red ware.

At the other extreme Majestic produced fewer stems (mean 2·5) and tubers (mean 17·3) with a low proportion of small tubers in treatment *c*. This variety rarely formed four or more stems per plant, which produced an increased number of smaller tubers. In treatment *a* the number of tubers was reduced, but there was an excessive proportion of large coarse tubers unfit for sale. The behaviour of Ulster Supreme was comparable to Majestic, and in both these varieties reducing the sprouts to one per set was unsatisfactory.

King Edward was intermediate between these extremes, but the amount of large ware was greatly increased by reducing the sprouts. Treatment *a* reduced the total number of tubers and increased the proportion of large ware. The behaviour of the two seed sizes in this treatment should be noted. Treatments *b* (large seed) and *c* (small seed) were practically identical, producing a mean of approximately three stems per set and similar numbers of tubers. Treatment *c* (large seed) tended to produce more stems and a greater number of tubers, ranging up to six stems and 43 tubers on a single plant. This treatment was unsatisfactory for ware production.

The number of stems formed per plant appeared generally to correspond to the number of sprouts per set planted, but with marked varietal differences. Considerable suppression of sprouting was noted. Varieties (King Edward and M.A.N.I. 480/51) which often produce a high proportion of small tubers benefited markedly from sprout reduction, whereas the others did not. Large seed tended to form more sprouts and stems than small seed[6,7] and a higher proportion of small tubers. Full details are reserved until it is possible to include the 1958 results, when a complete account of the work will be published.

Grateful acknowledgment is made to Mr. C. V. Dadd of the National Agricultural Advisory Service, Cambridge, for his help, to the Governors of this Institute for provision of facilities, and to the Ministry of Agriculture, Northern Ireland, for co-operation and for supplying part of the seed.

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Chromosome Breakage at High Radiation Dose-Rates

THE variation of the frequency of chromosomal aberrations as a function of radiation dose-rate has been the subject of numerous experimental investigations, and the results of such studies have been of considerable importance in formulating theories of the basic mechanisms of radiation action[1]. With the recent availability of radiation sources of great intensity, such as electron linear accelerators, and the development of reliable dosimetric techniques for use at these intensities, the extension of studies on chromosomal breakage into the range of the extremely high dose-rates has become feasible.

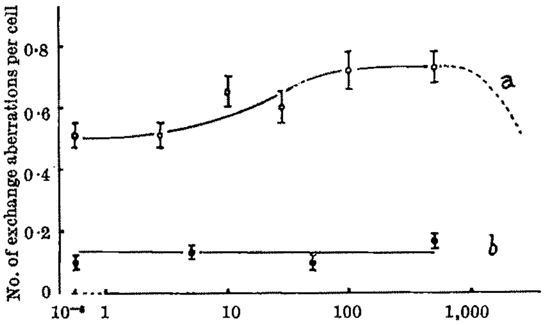

Fig. 1. Variation of the frequency of exchange aberrations with dose-rate for a constant dose of about 400 rads. *a*, In air; *b*, in nitrogen

An exploratory investigation of chromosomal breakage in microspores and pollen has been carried out at dose-rates up to 4×10^6 rads/sec. using the electron and X-ray beams from the 15-MeV. linear accelerator at St. Bartholomew's Hospital. Special ionization chambers in conjunction with 'Perspex' dosimeters[2] were used in the determination of the dose applied. The biological material has been *Tradescantia paludosa* (clone 3 of Sax), made available to us through the courtesy of Mr. George Lacour and the John Innes Horticultural Institution. Chromosome aberrations in *Tradescantia* microspores examined 4–5 days after irradiation have been studied in most of the work to date.

All results so far obtained indicate a definite and significant decrease in the frequency of aberrations at dose-rates of more than 10 rads/sec., for material irradiated in air. This decrease in the frequency of aberrations has been observed repeatedly for deletions as well as for exchange aberrations. Typical results obtained from one set of experiments are shown in Fig. 1, which relates to irradiations carried out in air and in nitrogen with 14-MeV. electrons. The dose was about 400 rads for both media. The dotted portion of the upper curve shows the expected frequencies of exchange aberrations at lower dose-rates reported by Wolff and Luippold[3]. The curve for irradiations in air shows that the frequency of exchange aberrations has a constant value over a range of medium dose-rates and falls off at both high and low dose-rates. In nitrogen neither the deletions nor the frequency of exchange aberrations decreases at high dose-rates.

At present there is no satisfactory explanation of the drop (40–50 per cent) observed at high dose-rates from the plateaux at medium dose-rates, although mechanisms involving recombination of secondary organic free radicals appear qualitatively plausible. An alternative explanation of this result based on partial temporary anoxia resulting from immediate consumption of oxygen under intense bursts of radiation has also been proposed. A preliminary experiment carried out under increased oxygen tension suggests that the second explanation may be correct.

A complete account of this work will be published elsewhere.

We wish to acknowledge financial support from the British Empire Cancer Campaign and the Treasurer and Board of Governors of St. Bartholomew's Hospital. We also wish to thank Prof. J. Rotblat,

head of the Linear Accelerator Research Unit at St. Bartholomew's Hospital, for his help and co-operation.

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Competition between Genotypes in *Drosophila melanogaster*

It has been shown by Birch[1] that the main competitive effect in *Drosophila pseudo-obscura* is between larvæ. Lewontin[2] studied the larval viabilities of various strains of *D. melanogaster* mixed with a white-eyed stock and found that the viability of a genotype is partially dependent on the genotypes co-existing with it.

In a two-point back-cross linkage experiment, the proportion of competing genotypes is different in each phase. Considering such an experiment for two factors *a* and *b* which are somewhat inviable in the recessive state, four genotypes are obtained in the offspring:

AB/ab, Ab/ab, aB/ab, ab/ab

In coupling, the most and least viable genotypes, *AB/ab* and *ab/ab*, predominate in the progeny, and hence under crowded conditions there will be a tendency for elimination of *ab/ab* flies. In repulsion, *Ab/ab* and *aB/ab* predominate and the main competition is between these two genotypes. The recombinants *AB/ab* and *ab/ab* will not compete with each other to any great extent but will compete mainly with the parentals. Hence the elimination of *ab/ab* will not be as great as in coupling. Thus in very crowded conditions a difference in the viability relations can be expected between coupling and repulsion.

Using the two sex-linked genes, white (*w*) and miniature (*m*), results for coupling and repulsion (Table 1) were collected for two-point backcrosses in *D. melanogaster* for three levels of competition which can be termed low, medium and high levels. For all levels, flies were mated for 48 hr. For the low level one pair was mated in a ½-pint milk-bottle, for the medium level one pair in a small vial, and the high level six pairs in a small vial.

Assuming no competition between larvæ, the ratios *wm* : + + and *w*+ : +*m* should not vary between coupling and repulsion. A simple contingency χ_1^2 may be done within each level to test this (Table 2).

The only significant result is for the high level where the ratio *wm* : + + varies between coupling and repulsion. In coupling, the *wm* flies are of much poorer viability than the + + flies, but in repulsion this is not so. The less extreme contrast, *w*+ and +*m*, does not show any variation between coupling and repulsion.

Table 1. Results for *w–m*

		wm	*w*+	+*m*	+ +	Total
Low	*C*	478	236	211	483	1,408
	R	318	529	569	289	1,705
Medium	*C*	409	205	236	407	1,257
	R	190	407	424	200	1,221
High	*C*	506	288	300	659	1,753
	R	580	976	1,062	553	3,171

C, Coupling; *R*, repulsion.

Table 2. χ_1^2 Tests for *wm* : + + and *w*+ : +*m* within Each Level of Competition

Levels	*wm* : + +		*w*+ : +*m*	
	χ_1^2	*P*	χ_1^2	*P*
Low	0·71	$0·3 < P < 0·5$	2·53	$0·1 < P < 0·2$
Medium	0·16	$0·5 < P < 0·7$	0·62	$0·3 < P < 0·5$
High	13·56	$P < 0·001$	0·18	$0·5 < P < 0·7$

This difference arises as a result of differential competition between larvæ according to the proportions of competing genotypes present. The implication of the viability of a genotype varying according to the competing genotypes has not been stressed, although Haldane[3] deals with it in an early paper. In natural conditions, where competition is much more severe than in artificial laboratory conditions, such effects must assume some importance. Thus selective advantages and disadvantages of a gene or genotype must be considered in relation to the food available, and the types and proportions of the other genotypes in the population.

Further discussion with additional results will be published elsewhere.

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May 31.

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Effects of Environment (Radiation, Substrate and Allelic Genes) on the Melezitose Gene in *Saccharomyces*

The melezitose locus (*MZ*) in *Saccharomyces* controls the formation of the adaptive enzyme, melezitase, which acts on five substrates: turanose (*T*), maltose (*M*), sucrose (*S*), methyl-α-D-glucopyranoside (*G*), and melezitose (*Z*), each of which may serve as an inducer of melezitase[1-3]. Seven different variations (alleles) of this gene are known and are designated *TMSGZ*, *TMSGz*, *TMSgZ*, *TMSgz*, *TMsgz*, *Tmsgz* and *tmsgz*[3]. The capital letters indicate the substrates which are capable of inducing melezitase in glucose-grown cultures. Cells in which melezitase has been induced by one of the substrates to which it responds adaptively are able to split the substrates which do not act as inducers in that specific genotype without further adaptation. For example, a glucose-grown culture carrying *TMSgz* responds to neither methyl-α-D-glucopyranoside nor melezitose, but splits both these substrates after exposure to turanose, maltose or sucrose.

The first evidence of the *MZ* series came from hybridization experiments. The various genes produced by hybridization were inferred to have resulted from gene conversion in the hybrid since they were stable in the vegetative condition and arose at meiosis of heterozygotes only.

Five genes of the *MZ* series were obtained by ultra-violet radiation of *TMSGZ*. The limited kinds which were produced by gene conversion and ultra-violet radiation indicate that alterations of the gene

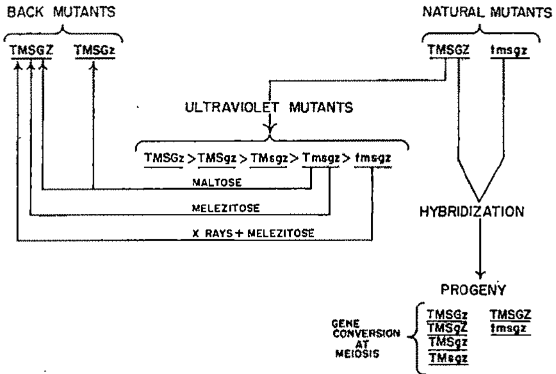

Fig. 1

occur in an orderly manner[3]. This view was further supported by the relative frequencies of the different types of mutants induced by ultra-violet radiation.

Back mutation of the gene occurred from 'recessive' to 'dominant' when the ultra-violet-induced mutants (*tmsgz* excluded) were exposed to substrate which they could not utilize. The gene *tmsgz* had proved refractory to back mutation by substrate alone (or by ultra-violet and substrate). Mutations of *tmsgz* back to *TMSGZ* were induced by the combined action of X-rays and substrate[4]. The linear mutation–dose-response curve for X-ray-melezitose induced back mutants, and the failure to detect intermediate variations of the gene indicates that the mutation from *tmsgz* to *TMSGZ* is a single event (Pittman, D., Lewis, C. H., and Lindegren, C. C., in preparation). The synergistic effect of X-rays and melezitose being necessary to induce the single event suggests that X-rays render the gene mutable and melezitose specifies the mutation. The five traits of the back mutant are transmitted as a single gene in hybrids. The cleavage-rate of melezitose by X-ray-induced back mutants was lower than that of a wild type strain, indicating that the 'new' gene was not so potent functionally as the 'original' gene.

Fig. 1 is a diagram of the various manifestations of the gene and the effect of various agents upon them. Ultra-violet radiation effects the degradation of *TMSGZ* to produce five different genes with the relative frequencies: *TMSGz* > *TMSgz* > *TMsgz* > *Tmsgz* > *tmsgz*. Each of the 'degraded' genes is characterized by the inability of the mutant to respond adaptively to one or more of the inducing substrates by the induction of the enzyme melezitase. The fact that only five of 31 possible genes are produced by ultra-violet radiation of *TMSGZ* supports the view that the degradation of the gene is an orderly process, and that the gene is limited in the number of its manifestations. The 'intermediate' genes respond to substrate alone (without the mediation of radiation) by back mutation. Back mutation of *Tmsgz* on melezitose produced only *TMSGZ* while back mutation of *Tmsgz* on maltose produced both *TMSGZ* and *TMSGZ*, indicating that substrate specifies the back mutation to a limited extent. The fact that back mutation from those induced by ultra-violet radiation can occur led to the inference that the phenotypes of the intermediate genes do not result from deletion but rather from alteration of the gene. The gene *tmsgz*, which is incapable of responding as an inducer to any of the substrates, is incapable of reverse mutation by exposure to substrate only. Although *tmsgz* cultures are refractory to back mutation when plated on the five substrates, if exposure to substrate is preceded by X-irradiation, back mutation occurs. It is inferred that X-rays and the substrate act synergistically and that X-rays render the gene mutable and substrate specifies the mutation which shall occur. In the absence of either X-rays or substrate, mutations occur at a very low rate. The X-ray-substrate back mutants are of two types—either the totipotent *TMSGZ* or $TM^vSG^vZ^v$, the latter being variable in their capacity to respond to the inducers maltose, methyl-α-D-glucopyranoside and melezitose. The variable mutants may be originally *TMSGZ* but may lose some recently acquired capacities rather readily. The stability of *S* may mean that a mutation at another locus (*SU*) had occurred. These variable mutants are under further investigation to determine the nature of the instability induced by radiation. The reconstituted *TMSGZ* gene is functionally less active than the original gene. These 'restorative' mutations resemble the repair of a damaged locus rather than the construction of a 'new' gene. A capacity not found in the genus might be introduced by exploitation of the combined effects of unequal crossing and the synergistic effects of substrate and radiation.

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May 15.

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Abundance of Pogonophora

A previous communication[1] reported the occurrence of Pogonophora in the Atlantic. Since then another cruise has been made on R.V. *Sarsia*, and more preserved material examined. Species of *Siboglinum* have now been taken at six stations along the continental slope between lat. 47° 56′ N., long. 7° 56′ W. and lat. 48° 32′ N., long. 10° 11′ W. at depths ranging from 300 to 710 fathoms, and specimens of at least three of them brought back alive to the laboratory. Species of the same genus have also been found in bottom samples taken by Mr. N. A. Holme in 1956 at depths of only 80–90 fathoms off Dingle Bay on the west coast of Ireland.

Clearly, these interesting relatives of the chordates must be widely distributed in communities on muddy bottoms, and not only in deep water. It is surprising that they have escaped previous notice, as the areas where they have now been found were among the first to be dredged and trawled over by marine zoologists. No doubt the superficial resemblance of the tubes to the fibres used in dredge and trawl netting has hindered earlier recognition.

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June 6.

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[1] Southward, A. J., and Southward, E. C., *Nature* [181, 1607 (1958)].

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Zoologist (with a degree) in the Physics Department to assist in studies of effects of radiation on bone—The House Governor, Westminster Hospital, London, S.W.1 (July 29).

Assistant Lecturer in Soil Physics in the Department of Agricultural Sciences—The Secretary, School of Agriculture (University of Nottingham), Sutton Bonington, near Loughborough (July 31).

Assistant Lecturer in the Department of Pharmaceutics, and an Assistant Lecturer in the Department of Pharmaceutical Chemistry—Clerk to the Council, School of Pharmacy (University of London), P.O. Box 125, 29/39 Brunswick Square, London, W.C.1 (July 31).

Technical Officer (A.I.M.L.T. or with a science degree, competent in blood group serology, and preferably experience in plasma drying and/or fractionation) to act as Deputy to the Chief Technical Officer—The Medical Director, National Blood Transfusion Association, Pelican House, 52 Lower Leeson Street, Dublin (August 6).

Research Fellows in Chemistry, Metallurgy, Electrical Engineering and Physics—The Registrar, College of Technology, Gosta Green, Birmingham 4 (August 7).

Assistant Experimental Officer (female, with a degree in a biological subject and practical experience in bacteriological methods and techniques), for supervisory duties in media preparation and general laboratory management and to assist in experimental work on ecology of soil micro-organisms—The Secretary, Rothamsted Experimental Station, Harpenden, Herts (August 9).

Assistant Lecturer or Lecturer in the Department of Inorganic and Physical Chemistry—The Registrar, The University, Liverpool (August 9).

Demonstrator in Botany—The Registrar, The University, Leeds 2 (August 9).

Lecturers or Assistant Lecturers (with an honours degree in mathematics and research experience in either pure mathematics or mathematical physics) in Mathematics—The Registrar, Manchester College of Science and Technology, Manchester 1 (August 14).

Animal Physiologist (graduate with qualifications and research experience in physiology) at Canterbury Agricultural College, University of New Zealand, to undertake research work with animals and some lecturing duties—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (August 15).

Assistant Lecturer (preferably with special interests in human geography) in Geography—The Assistant Registrar, The University, Edmund Street, Birmingham 3 (August 16).

Post-doctoral Fellow (Ph.D. standard with research experience in organic chemistry) in the Department of Organic Chemistry to undertake work on metabolics of marine micro-organisms—The Registrar, The University, Liverpool (August 16).

Research Officer (with an honours degree in science (majority in botany and plant physiology) or agricultural science, and postgraduate experience in relevant fields) in the Plant and Soils Research Laboratory, Division of Plant Industry, C.S.I.R.O., Brisbane, Australia, to conduct a research programme on the effects of the climatic factors of the environment on the growth and reproduction of subtropical and tropical pasture and crop plants, with particular attention to the effects of temperature and photoperiod—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 146/108 (August 16).

Senior Lecturers or Lecturers (male, with an appropriate first- or second-class honours degree and preferably teaching experience) in Mathematics (preferably Applied Mathematics), Mechanical Engineering, Electrical Engineering, Radar and Telecommunications, and Engineering Physics at the Royal Military College of Science, Shrivenham, Berkshire—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A262/8A (August 18).

Lecturer in Philosophy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 22).

Lecturer (with at least a Master's degree in chemical engineering and some experience in the teaching of chemical engineering instrumentation) in Chemical Engineering at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 22).

Geologist (with an honours degree in geology requiring a four-year course at a recognized university, and preferably previous experience) with the Southern Rhodesia Government—The Secretary (R), Rhodesia House, 429 Strand, London, W.C.2 (August 23).

Chemists, Scientific Officer or Senior Scientific Officer Grade (with a first- or second-class honours degree in chemistry or equivalent, and for Senior Scientific Officer posts, some research experience) at the Road Research Laboratory (D.S.I.R.), Harmondsworth, Middlesex, for research into the use and performance of bituminous road materials and on problems arising from the presence of organic matter in soils—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.475/8A (August 29).

Demonstrator in the Department of Botany—The Registrar, The University, Nottingham (August 29).

Curator (preferably aged 35–40, with an honours degree in zoology) of Mammals—The Secretary, Zoological Society of London, Regent's Park, London, N.W.1 (August 31).

Demonstrator in Physics—The Registrar, Trinity College, Dublin (August 31).

Lecturer (with an honours degree in chemistry and preferably experience in radiochemical techniques) in Chemistry at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, August 31).

Assistant Lecturer in the Department of Geography—The Registrar, The University, Liverpool (September 6).

Lecturer in Microbiology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 8).

Chair of Industrial Microbiology—The Secretary, University College, Dublin (October 1).

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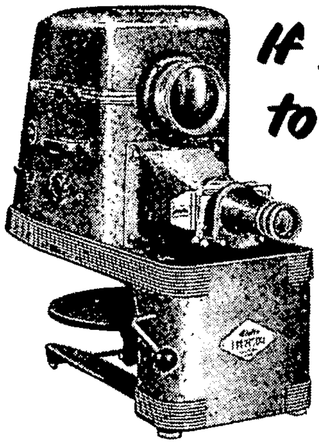

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NATURE

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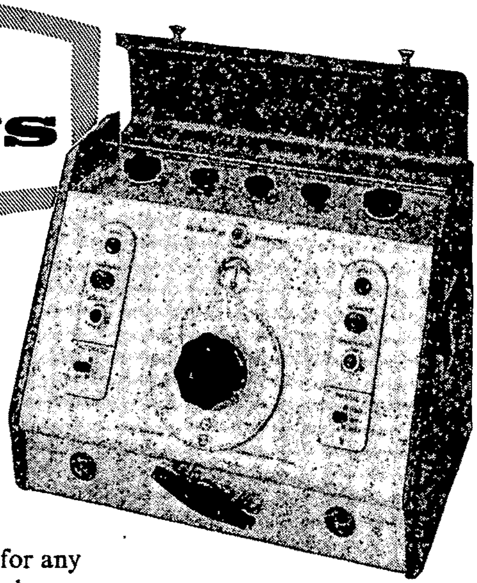

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INVENTION AND RESEARCH

THE report which Prof. C. F. Carter and Prof. B. R. Williams prepared last year on behalf of the British Association was concerned with the factors which determine the speed of application of science, and it laid stress on the importance of a favourable environment. Competition alone was not regarded as a sufficient condition for technical progress ; there must also be provision for fundamental research as well as for industrial research, and adequate educational provision for the training of technologists. Apart, however, from a glance at the patent system, which suggested that the bias of the patent system is towards the disclosure and use of inventions rather than their concealment or suppression, the report was not concerned with the origin of inventions and whether the industrial and social framework to-day was such as to stimulate a free flow of inventive genius and the functioning of creative minds.

The latter could be described as the main theme of a subsequent book by Prof. J. Jewkes, D. Sawyers and R. Stillerman[*]. It is not so much concerned with the origin of ideas, the functioning of the creative mind, or even with the elements of design and chance in discovery and invention, except in so far as these are affected by the system in which they function. What it really seeks to examine is the place of the individual in industrial society to-day, and whether the forms which the organization of research and development commonly takes have been beneficial or otherwise to inventive work, or whether the ostensible advantages of team-work and large-scale organization have been offset in some tangible or intangible way. To that extent the book overlaps some of the discussion in the symposium on "The Direction of Research Establishments" held at the National Physical Laboratory in September 1956[†].

Clearly, the most effective use of scientific and technical man-power demands that we should be clear as to the essential conditions required, just as our industrial efficiency requires that organization should be appropriate to serve those and other needs. It is important that, as this book suggests, the way this or that policy may influence the flow of invention should be considered, and the development of a European Free Trade Area could well give a keener interest in studies in a field of which we know relatively little, though whether ignorance is quite as profound as is here asserted might be questioned. Any necessary connexion between the growth of scientific knowledge and that of technology and invention is not easy to trace, and the need for more actual knowledge about technical and economic change is undeniable. A community, for example, seeking to encourage innovation has little guidance as to how best to proceed, what institutional framework will most effectively stimulate and encourage the men with powers of originality, most rapidly distinguish between the channels open to progress and the blind alleys, and most thoroughly reap the economic harvest from innovation.

Prof. Jewkes and his colleagues do not go very deeply into the problem which confronts every society of how to balance continuity and stability with change and receptivity to new ideas. It is with a comparatively limited aspect of technological change that they are concerned ; but they make the fair comment that industrial societies have shown little originality or ingenuity in creating institutions to ensure that all new ideas are caught and nothing lost, and have also not been prolific in devising institutions to encourage invention, though the patent system has been challenged more often than this book would suggest. Again, the decision which every society makes about the proportion of its resources to be devoted to research and invention involves fundamental questions about the ends for which society should strive ; and even if it could be shown that invention is to any significant extent a calculable, predictable element which could be embodied into the conscious planning of social and economic activity, that decision is unlikely to be appreciably affected by knowledge of the circumstances in which industrial innovations have arisen in modern times, and of any important changes in their sources between the present and the past century.

Accepting the distinction drawn here between invention and development, with which the book is only to a limited extent concerned—although as in all technology the criteria of achievement in invention is applied ultimately by the user and not, as in science, by the scientist—invention still stands nearer to science than to technology in the development sense. This study of factors which stimulate inventiveness is accordingly of deep interest to all concerned with the conditions which promote creative thinking and with the genesis of ideas. Moreover, if we can answer the questions which the authors put to us, we have still far to go to solve the major problems of development and overcome the difficulties and weaknesses in industry, and in government, to which Prof. Carter and Prof. Williams directed attention. In spite of casual remarks which display the bearing of such societies as the Lunar Society and the Manchester Literary and Philosophical Society on the intermingling of the scientists and technologists of the day, nothing like enough stress is laid upon the importance both to science and to technology of free communication. To provide for such intercourse and mingling and to establish the conditions in which knowledge and criticism are freely exchanged appears to be the vital first step; and when this is secured, the question of the individual or the research team appears to be relatively unimportant.

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[*] The Sources of Invention. By John Jewkes, David Sawers and Richard Stillerman. Pp. xii+428. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1958.) 31s. 6d. net.

[†] The Direction of Research Establishments: Proceedings of a Symposium held at the National Physical Laboratory on 26th, 27th and 28th September, 1956. Pp. vi+422. (London: H.M. Stationery Office, 1957.) 25s. net. See also *Nature*, 178, 964 (1956).

What deserves more attention than it receives, and could receive, in this inquiry is the improvement of such communications. Scientific and technical literature is indeed extensive, but it is scarcely so easily and cheaply obtained as this book suggests, and some of the conditions which make it less accessible and more expensive are an indirect result of Government policy. So too, while those who are not employed in scientific and technical institutions but are frequently connected with scientific societies and institutions may also derive aid from industrial research associations or government research associations, it should be remembered that it is Government policy which has frustrated the project for a Science Centre in London and also, through the recent change in rating policy, jeopardized the existence of numerous scientific societies.

While it could not be argued that, in general, extensive and detailed records of scientific and technical knowledge are denied to the independent worker of calibre and purpose, it could certainly be shown that Government policy over the past ten years has made the dissemination and discussion of such knowledge more difficult, both for the individual and for the member of a research team. What stands out above all from this study is that the real danger to invention and to creative work arises from the multiplicity of such neglect on the part of the administrator. There is little more evidence to be found for the view that the day of the individual inventor is done or that effective prediction of inventions is possible; the real dangers in team-work arise when attempts are made to organize research in the same way that manufacture is organized and the conditions in which research is most effective are ignored. Even team-work in research is the result of the co-operation of individuals working under conditions which allow full-play to their individuality in pursuit of the common goal.

When all allowance is made for the tendency, due to the growing cost of equipment, for research to become a matter for institutions rather than individuals, any dangers inherent in the consequent increased scale of research departments may be offset by the greater opportunities which such institutions can offer for the bringing together of workers in different disciplines. The importance of such cross-fertilization of minds was well brought out in the last annual report from the President of the Carnegie Institution of Washington; but there is a further point which needs to be emphasized, and that is the value of a diversity of institutions. That is important as helping to offset the danger that any one type of institution may become rigid and over-organized; it also meets the problem of helping the individual inventor, whose very originality often makes him difficult to fit into a particular type of organization.

No serious attempt to further inventiveness can fail to take account of those qualities which characterize most inventors, whether they work inside or outside an institution, and which also have something in common with the characteristics of the research worker. To both of them assistance must be given largely on their own terms, and in a way that does not frustrate or destroy originality and initiative; yet it is probably true that this has been—and is—widely neglected. Nevertheless, the influence of that factor alone may well outweigh that of size and organization as such. Whether or not the inventive ability of the community is being increasingly absorbed into organized research institutions, that of itself need not imply that inventors are less free to pursue their own ideas. It is not necessarily a disadvantage that they are less dependent on their own resources, nor is there any evidence that if they are less directly the recipients of the gains to be made from their inventions they are in consequence likely to be less inventive.

Broadly speaking, however, the bias of Prof. Jewkes and his colleagues appears to be against the view that the inventive ability of the community can only be put to the best use if it is increasingly set to work in organized research institutions. In challenging the belief that the day of the individual inventor has gone, they appear to swing too far against the research institution or department. There will always be individuals who will not fit into an organization, and it is important that society should make due provision for such lone individuals or eccentrics. The growing importance of the inventor with a professional training in science and technology is not likely to eliminate this factor, though it may simplify the problem of helping him.

Whether as much importance can be attached to the numerical incidence of inventions within or without the main research institutions or centres is, however, doubtful. If the prediction of invention is difficult, the identification of inventive talent before it has manifested itself is no less impracticable, and unless that is possible the element of chance may well vitiate all the numerical comparisons. The important thing is to see that the inescapable coordination and administration, both in industry and in society as a whole, are as dynamic and creative as possible, and to provide the framework within which the individual can express fully his creative and inventive powers.

Apart from this, the picture of large and small industrial laboratories presented as essentially authoritarian and mediocre bodies is open to challenge. Many of them are far from lacking the atmosphere necessary for creative work, and the discussion on creative work at the symposium on the direction of research establishments already referred to indicates that managers are often fully alive to the significance of such factors. Prof. D. J. van Lennep suggested, in fact, that creative research workers are less dependent upon their environment, less rigid and less dogmatic, as well as marked by a characteristic time perspective, perceiving the future as fraught with possibilities which they themselves could help to realize. Prof. M. I. Stein, from a study at the University of Chicago of factors influencing the creativity of industrial research chemists, suggested that creativity is a result of social environment and processes occurring within the individual; in his view, although we need more knowledge of the way in which environment affects a man's creative powers and of what psychological factors, in a satisfactory environment, stimulate creativity, adequate equipment, a congenial intellectual society and the secure livelihood which the research institution provides are to-day vital requirements for creative activity. Without them the essential tranquillity and concentration on the problem in hand are scarcely possible.

The discussion at the National Physical Laboratory rather than that of Prof. Jewkes and his colleagues seems to point the right way and to identify the problems that require examination. Whether science is playing a greater part in invention and whether inventions are due more to accidental discoveries than to rational planning and research seem to be of secondary importance. Even if the big corporations and research teams are replacing the lone inventor with limited resources, we still need to give much fuller attention to the conditions which foster creative work and invention. It is true that as one aspect it should be considered whether the growth in the scale of invention and development, of government-sponsored research and even changes in university education may tend to diminish invention by increasing resistance to change; quite rightly attention is directed to the value of the uncommitted mind and of the way the grooves of accepted thought may hinder invention. We need, however, to know more about the optimum size of research groups, the way a group functions in developing ideas, and of the effect on such a group and on himself of a really gifted individual.

We have already a good deal of information, of which the Government seems to be unaware, which if acted upon could minimize or eliminate the major dangers to which Jewkes *et al.* direct attention. It is already recognized that research establishments, industrial or academic, can never be too vigilant in fostering original thought; but we could probably make fuller use of the known techniques of selection to place those with creative talents in places where they have the most adequate opportunity of expression. Moreover, the tendency of modern management to become catalytic rather than directive is also in line with what is demanded in the most effective use of creative and inventive talent.

It is in such ways as these that the sources of invention can be kept free and unblocked, and it should be noted that in this whole process the improvement of communications plays a vital part. This is not simply an educational issue, though the development of technological and technical as well as university education could contribute much to a surge of understanding that would increase our ability to encourage and utilize the outflow of creative ideas. It is also a matter of administrative action and improving conditions in a field to which successive Governments have hitherto been indifferent.

That seems to be one of the ways in which immediate action could be taken, and in raising the question of the rating of scientific societies, the opportunity should be used to bring home to the Government the vital contribution which such societies still make to the communication of knowledge and the stimulation of ideas. Attention should be directed, too, to their part in publication, to the handicap which postal charges now place on such undertakings, to the urgent need for an adequate national policy for scientific and technical libraries, and to the practical value of a National Science Centre. Much could be done in ways such as these, while Prof. M. I. Stein and Prof. D. J. van Lennep pursue their studies at the Universities of Chicago and Utrecht. Meanwhile, Prof. Jewkes *et al.* have indicated further questions to which answers could well be sought; but the doubts he expresses as to the teamwork appear to be sufficiently answered by Prof. René Taton, approaching the subject from an entirely different angle in a fascinating essay, "Design and Chance in Discovery and Invention", published in *Impact* (Paris: Unesco) some two years ago. The dangers lie, in fact, not so much in the institution as in the way it is used, and the further knowledge continually being gathered as to how to use our institutions could well offset any increasing difficulty for the independent individual to exercise his inventive faculty, which Prof. J. D. Bernal believes is inherent in the nature of modern industry.

FROM DIVINE TO CONTINUOUS CREATION

Theories of the Universe from Babylonian Myth to Modern Science

Edited by Milton K. Munitz. (The Library of Scientific Thought.) Pp. x+437. (Glencoe, Ill.: The Free Press; Indian Hills, Colorado: The Falcon's Wing Press; London: George Allen and Unwin, Ltd., 1957.) 48*s.* net.

WITH the multiplication of courses on the history of science there has come from publishers an increasing and welcome flow of source-books and translations of all kinds, particularly of trans-Atlantic origin. For example, the McGraw-Hill series of 'readings' from classic originals in mathematics, physics, chemistry and so on has been widely known and used. Now Mr. Milton K. Munitz, of New York University, has had the excellent notion of producing a similar set of 'readings' to illustrate the evolution of cosmological theories. In his volume the extracts are somewhat longer and more complete than in some of its predecessors—a point in its favour; and he has not chosen from among contemporary sources only, but has reprinted passages from recent historians and expositors. This seems a less satisfactory innovation. The works of writers like Cornford, Dreyer or Francis

Johnson can rarely be so very inaccessible to students or even to the general reader; and the inclusion of the interpretation of some historical phase by a single scholar in a collection of this kind, however eminently enlightening his views may be, is likely to set a stamp of infallibility upon them. In Mr. Munitz's book the only pieces on the period between Ptolemy and Copernicus are twenty-four pages from Dreyer's well-known history of planetary theories (available for some time in a cheap reprint) and an extract of three pages from Nicholas of Cusa's "De docta ignorantia". Dreyer was a learned and careful writer; but he wrote of almost everything medieval in terms of contempt, and the section here reprinted concludes with Dante. It would have been more just to contrast the primitive conceptions of some medieval Christians with the rational and open discussions of such a philosopher as Oresme in the fourteenth century. Medieval philosophers had more serious problems than the calculation of the number of angels who could dance on a needle-point; medieval cosmologists had more serious problems than determining the site of heaven and hell—though it is unclear why this should not be a matter of interest to a professed Christian.

The choice of authors in an anthology like this is virtually dictated, and proceeds (as the sub-title indicates) from Jacobsen's account of Babylonian creation-myths through the Ionians, the famous later Greeks, Copernicus, Galileo, Newton, Herschel and others to a relatively much more ample extraction from the modern cosmologists—Willem de Sitter to Fred Hoyle. To these last more than a third of the whole book is devoted. Within the range of authors an anthologist has a freer choice: Mr. Munitz has usually, though not invariably, hit upon passages that contain the kernel of a conception. His Lucretius is fascinating; his Ptolemy demonstrates the obvious fact that Ptolemy was great as a technical astronomer, not as a creative thinker; his Galileo, unfortunately, is rather dull—a statement of the Copernican system, certainly, but not an introduction to the intellectual exhilaration of Galileo's writings, nor indicative of his great cosmological theme, that the universe is a system of physically similar bodies, subject to the same physical laws. It was a pity to omit Descartes, for his idea of the universe changing in time. Again, the passages taken from Newton are well worthy of study, including the four letters to Bentley; yet one misses inevitably the foundation of exact science that underlay Newton's wider (and more vulnerable) ideas, and that constitutes the solidity of the "Principia". It is indeed difficult to see how cosmological theories can be presented in manageable form along with their necessary substratum in the observable facts of astronomy and astrophysics; but it is by its relation to the available substratum of science that any theory of the universe must be judged as a contribution to the intellectual development of its time.

One cannot say that there is much here that is not accessible fairly readily and in English; nevertheless, it is valuable to have typical passages reprinted, and the close juxtaposition of conflicting arguments is highly stimulating. The collection will be a convenient introduction to one area of controlled speculation which has always furnished a major theme in the growth of science. As such, it is worthy to stand by others of the same kind as a volume to which both teachers and students will often turn with profit.

A. R. Hall

NICOLAUS STENO

Nicolaus Steno and His Indice

Edited by Gustav Scherz. (*Acta Historica Scientiarum Naturalium et Medicinalium*, Vol. 15.) Pp. 314. (Copenhagen: Ejnar Munksgaard, 1958.) 32 Danish Kr.

The life of Nicolaus Steno (1638–86) falls, broadly speaking, into two periods, the scientific (to 1674) and the priestly. A notable figure among the many great scientists of that formative period, the seventeenth century, Steno made important contributions to human and comparative anatomy, embryology, geology and palæontology; and his studies of crystals of quartz have earned him the title of 'Father of Crystallography'.

In this small volume, a concise biography by G. Scherz is followed by essays by six other contributors: "Nicolaus Steno's Contribution to Zoology", by Ragnar Spärck; "Nicolas Sténon Paléontologiste", by Rémacle Rome; "Nicolaus Steno and Scientific Geology", by Axel Garboe; "Niels Stensen und die Kristallographie", by Heinrich Tertsch; "Niels Stensen und der Cartesianismus", by Adolf Faller; and "The Influence of Nicolaus Steno on the Development of Geological Science in Britain", by V. A. Eyles.

The essays by Dr. Garboe and Fr. Rome trace the development of Steno's notions of geological strata and his conviction that fossils are indeed the remains of living animals. These ideas, and similar ideas developed independently by Robert Hooke, led to a long-drawn-out argument over the origin of fossils; Dr. Eyles reviews the beginnings of this controversy, with particular reference to the independence of Hooke's and Steno's work and to the continued appreciation and citation of Steno's arguments by British scientists when they were forgotten over much of Europe.

Of Steno's pioneer work in crystallography, his discovery of the constancy of crystal angles throughout all variations of habit is well known, but it is less generally realized that his studies of ghost quartz and of zoned inclusions led him to conclude that crystals grow, and grow by apposition of new layers on the several faces, a very different mode of growth from that of living beings; he noted that the rate of accretion varies on faces belonging, in modern terms, to different forms, and endeavoured to account for the striations on the prism faces of quartz, and the tendency to a tapered prismatic habit. Dr. Tertsch gives an excellent review of Steno's work on quartz, pyrite and hæmatite crystals, and points out that Steno's measurements were not wholly interfacial angles as is commonly assumed; some at least were interzonal (inter-edge) measurements.

Steno's scientific work was largely based on two collections of natural objects, his own and that of the Grand Duke, which are known to have been housed in Florence; it is probable that some at least of this material still survives, though none can now be traced with certainty. But copies of a catalogue exist that was almost certainly originally written or dictated by Steno; the descriptions of crystals, minerals and fossils in this catalogue are of great interest, and it forms one of the most useful features of this book. Dr. Schertz has collated and reprinted the Italian text with an English translation and with extensive and valuable notes.

M. H. Hey

PHARMACOPŒIAS AND FORMULARIES

British Pharmacopœia 1958

Pp. xxvi+1012. (London: The Pharmaceutical Press, 1958. Published for the General Medical Council.) 63*s*. net.

British National Formulary, 1957

Pp. 226. (London: British Medical Association; and the Pharmaceutical Society of Great Britain, 1957.) Standard edition 6*s*. 6*d*.; Interleaved edition 10*s*.

British National Formulary, 1957

Alternative edition based on a Pharmacological Classification. Pp. 245. (London: British Medical Association; and the Pharmaceutical Society of Great Britain, 1957.) 7*s*. 6*d*.; Interleaved edition, 10*s*. 6*d*.

The Extra Pharmacopœia

Vol. 1 (Martindale). Twenty-fourth edition. Pp. xxx+1695. (London: The Pharmaceutical Press, 1958.) 65*s*.

IT is a hundred years since the General Medical Council became responsible for publishing "The British Pharmacopœia". The present issue is the ninth since that date and it becomes official from September 1 when the standards laid down for the medicaments included will be legally enforceable and supersede those of the eighth edition of 1953 and its addendum of 1956. The work of selecting drugs for inclusion in "The Pharmacopœia" and of setting standards for them is delegated to the British Pharmacopœial Commission assisted by expert committees, and it is the present intention that a new edition should be produced every five years. Each succeeding issue marks the trend of medical practice from the empiricism of the nineteenth century (dependent mainly on natural products for drugs) towards the physician's ideal of using pure substances of known and precise pharmacological action. Belladonna root, mercury ointment and quassia are well known substances which at last, with 135 other items, have fallen from official favour to make way for 160 new monographs, including such names as acetazolamide, prednisolone, and tetracycline hydrochloride. It is interesting to note that phenylbutazone, which was considered sufficiently well established as a therapeutic agent to be included in the 1956 addendum, is deleted in this edition, presumably because of adverse clinical reports about it in the past two years. For the first time radioactive materials, the sodium salts of radioiodine-131 and of radiophosphorus-32 appear as monographs.

The break with tradition, begun in 1953, of using English titles for monographs instead of Latin headings has continued, and in this issue many of the English titles have been simplified. However, many modern medicaments are produced under registered trade marks and patents held by individual firms which give their products names different from those selected by the Commission. To aid those in medical and pharmaceutical practice to identify brands of official medicaments, the Commission has authorized the publication of a pamphlet, listing approved names and the other names by which a medicament may be known, for use in conjunction with the new pharmacopœia.

Standards for drugs and medicaments naturally become more exacting and complex with each succeeding issue of "The British Pharmacopœia" and must of necessity refer to equally important standards of other official bodies. Close collaboration between such bodies is to be expected and it is disappointing to find that determinations of viscosity are based on apparatus described in British Standard 188 of 1937 instead of the current issue of 1957. Apart from this lapse I have great admiration for the general quality of the latest publication. The Commission and especially the editor are unreservedly to be congratulated on a fine production.

Similar congratulations should be extended to the Joint Formulary Committee for producing "The British National Formulary, 1957". This is the fourth edition of what has hitherto been known as the "National Formulary", the change in title being introduced to avoid confusion with the United States book of standards of the same name. Whereas "The British Pharmacopœia" is primarily a collection of specifications for drugs and is to be found on the manufacturer's and analyst's bookshelves rather than in the consulting room, "The British National Formulary" is the constant companion of every physician and pharmacist in general practice. The standard edition follows the traditional pattern for this pocket-book, containing notes for prescribers, useful information on the treatment of poisoning and identification of medical gas cylinders, as well as the formulary of medicaments set out in pharmaceutical types (mixtures, injections, eye-lotions, tablets, etc.). This classification, however, while of great use to the pharmacist, can be inconvenient for the prescriber who thinks of his medicaments in terms of the action that they will produce. To meet this situation an alternative edition has been issued based on a pharmacological classification, with added comments on the use and reactions of the drugs listed in the standard edition.

However useful the pharmacological edition of "The British National Formulary" may be, it must of necessity remain a pocket-book, limiting the scope and the amount of information which can be incorporated. The need for a comprehensive reference book giving medical and pharmaceutical information on the majority of medicaments in present use is obvious. This need has been filled for many years by "Martindale's Extra Pharmacopœia", which first appeared in 1883 as one volume. Such has been the progress of medical knowledge that by the fifteenth edition in 1911 the information to be incorporated required the work to be split into two parts, Vol. 1 being devoted to the medical and pharmaceutical properties of medicaments and Vol. 2 to descriptions of ancillary subjects such as analytical standards, hæmatology, sterilization and disinfection, etc. The twenty-fourth edition of Vol. 1 is completely rewritten and is probably the most useful work of reference available in this field to-day. The keys to the book are the general index containing nearly 20,000 entries and the therapeutic index indicating possible treatment for nearly 800 medical conditions. I noted with pleasure that although "Martindale" was published only one month after "The British Pharmacopœia 1958", the co-operation between those responsible for the two books has been such that the main changes introduced by the official standard are indicated in a special section (and, more important, in the index) of the "Extra Pharmacopœia". In addition, twenty-four other pharmacopœias and related publications from all over the world have been examined and relevant material noted. Careful editing has been necessary in the selection of abstracts referring to specific-substances and this has been admirably executed. This book is an essential part of the libraries of all who are connected or interested in any way whatsoever with medicine and pharmacy.

DAVID TRAIN

SOCIAL CHANGE IN SIMPLER SOCIETIES

Yulengor

Nomads of Arnhem Land. By Wilbur S. Chaseling. Pp. xxvi+173+13 plates. (London: The Epworth Press, 1957.) 21*s*. net.

Easter Island

A Stone-Age Civilization of the Pacific. By Dr. Alfred Metraux. (Translated from the French by Michael Bullock.) Pp. 249+16 plates. (London: Andre Deutsch, Ltd., 1957.) 21*s*. net.

Work and Life on Raroia

An Acculturation Study from the Tuamotu Group, French Oceania. By Dr. Bengt Danielsson. Pp. 244+7 plates. (London: George Allen and Unwin, Ltd., 1956.) 25*s*. net.

Social Change in the South Pacific

Rarotonga and Aitutaki. By Prof. Ernest Beaglehole. Pp. x+268. (London: George Allen and Unwin, Ltd., 1957.) 28*s*. net.

THE theoretical and the practical importance of the social changes that have been taking place in the technologically undeveloped communities have led to the production of many books on the subject in recent years. These four works deal with the results of Westernization on indigenous peoples in Polynesia and in Northern Australia. Three of them, concerned with agricultural Polynesian communities, are by professional anthropologists; one, on the Arnhem Land nomads, is by a layman.

"Yulengor"—the name is the East Arnhem Land equivalent for aboriginal nomads—has been written by a missionary of long experience in the region. He landed there in 1934, and the results of his close sympathetic observation over a number of years make extremely interesting reading. He describes the domestic life, the hunting and collecting economy of these still primitive people, their initiation, burial and other rituals, their magic, their creation myths. The treatment is not very systematic, but a useful introduction by Prof. A. P. Elkin supplies the framework of the aboriginal social structure. The picture presented is one of extreme simplicity of life. Mr. W. S. Chaseling states that "the daily life of the people has not changed in a thousand decades and still involves hunting with stone and wooden spears and stone axes for everything the nomad eats". But he also says that metal has been filtering into the country for two centuries, and this has made hunting for sea-animals—such as turtle and dugong—easier. Again, nearly all the people in his photographs wear a modicum of clothing. This and other evidence indicates what anthropologists are by now well aware of, that even here the primitive Australian has undergone considerable change in his mode of life through foreign contact.

Dr. A. Metraux's book is a craftsman's job. Easter Island has provided one of the popular mysteries of the world and, as Dr. Metraux says, many audacious solutions to its problems have been provided. He himself gives an admirably clear, sober outline of the whole situation. He describes the traditional culture of the islanders and the radical, often tragic, changes that the community has undergone since Europeans first called there. He indicates the problems of origin and function connected with the cultural remnants now left to us. He does not shirk the difficulties of the problems. In particular, his own interpretation of the mnemonic and symbolic function of the wooden tablets "carved with script" is given as definitely provisional. He is equally critical and firm about the various theories put forward by others about the origins of Easter Island civilization in external sources. His own conclusion, that Easter Island sculpture, including the great statues, represents a specialization of Polynesian culture—probably from a Marquesan source—favoured by particularly local conditions, is one which has strong anthropological support. The book is a condensation and revision of an earlier scientific monograph, and while primarily for the non-specialized reader, may be taken as an authoritative statement.

In "Work and Life on Raroia", Dr. B. Danielsson continues in scientific vein his study of the Tuamotu Island community among whom he landed, in company with his companions of the Kon-Tiki raft, in 1947. This study of the social and economic condition of the community of rather more than a hundred persons is very detailed and one of the most useful accounts of a Polynesian island economy which we possess. The author studied the modes of production, both for subsistence and for cash exchange, the land tenure, and the income and expenditure patterns of the people. He prefaces his analysis by a detailed examination of the demographic condition and of the history of their contacts with other cultures. The changes in the society have been considerable. Apart from concentration of residence in a single village, there has been a decrease in the size of kin groups, a high degree of individualization of work as a result of the introduction of a competitive money economy, and a breakdown of the former system of hierarchical authority. Surprisingly for Polynesia, a man who wants to build a house must pay the workers in money, at wages almost as high as in Tahiti. For such a small population, the analysis of the figures is perhaps over-elaborate and the data on social structure too thin. But as the author points out, so far very few anthropological studies have been made of modern Polynesian communities showing the ways in which individuals and groups have responded to the varying local conditions of contact. This work is a very useful contribution to the study of acculturation process in the Pacific.

The study of Rarotonga and Aitutaki by Prof. E. Beaglehole is of a much broader character—indeed, its title goes much further than its content. The author has had a great deal of experience in studying Polynesian communities already, and the results of this emerge in his penetrating analysis and comprehensive generalizations. He has supplemented the limited amount of field research he was able to manage with a careful examination of the historical records. Using both an anthropological and a psychological frame of reference, he has given a valuable study of the history of social change in these two communities. He has also suggested a typology for such change and singled out clearly the various major factors in the process. Much of his analysis is concerned with the part played by missionary and Government official in the island communities, but a very substantial part of the book covers their demography, their economy and their social structure. A concluding section relates his findings to the administrative problems of development and welfare that now urgently concern the New Zealand Government, which has the responsibility for care of these islands.

All these works are worth reading for their sincerity and insight into an important aspect of modern social process. RAYMOND FIRTH

A COMPREHENSIVE HANDBOOK ON THE CARE OF LABORATORY ANIMALS

The UFAW Handbook on the Care and Management of Laboratory Animals

Edited by Alastair N. Worden and W. Lane-Petter. Second edition, greatly enlarged. Pp. xix+951. (London: Universities Federation for Animal Welfare, 1957.) 70*s.* net.

EVERY scientist who uses laboratory animals should realize the importance of good stock husbandry. Technical, as well as humane, considerations demand that experimental animals be kept under the best possible conditions, for environmental irregularities can confuse experimental results. This publication contains a wealth of knowledge on the management of nearly all the species of animals used in laboratories, and can be used as a guide to their respective needs by any worker who is seeking detailed information. This second edition is far more extensive than the first, and the additional matter included comprises not only knowledge acquired during the past ten years, but also details of additional species. More than eighty recognized authorities have contributed, for each chapter has been prepared by a worker who is an expert on the subject with which it deals.

The first part of the book is devoted to general considerations which apply to nearly all species. Subjects covered include the legal protection of laboratory animals, the designing and equipping of animal houses, the principles of hygiene, breeding methods, feeding, handling, anæsthesia and euthanasia.

The second part is devoted to comprehensive accounts of the many different species which are used for experimental work, and more than fifty species are dealt with individually. This part is subdivided on the basis of zoological classification. The first group deals with the rodents and lagomorphs, including the guinea pig, the rabbit, and various species of voles, rats, mice and hamsters. The shrews and hedgehogs, which are insectivores, are next described. The carnivores, such as the cat, dog, fox, ferret, mink and marten, follow. The ungulates, including the sheep, goat, horse and pig, form another group, and in small groups on their own are the primates and marsupials. Among the bird species included are the fowl, pigeon and canary. Other groups covered are the reptiles, amphibia and fish, and a miscellaneous group of invertebrates. Finally, some notes are given on more than twenty other species not dealt with in detail.

The information on each species is clearly set out, and most chapters contain information on accommodation, feeding, breeding, handling and disease control. A comprehensive list of references is given at the end of each chapter. The amount of space devoted to each species has been carefully controlled, and a well-balanced book has resulted. There is both a subject and an author index. The book is illustrated by clear photographs and diagrams dealing particularly with various types of cages and equipment.

This book will undoubtedly be widely read by scientific workers who use experimental animals, and could, with advantage, be provided as a standard reference book in all institutes where laboratory animals are kept. The contributors are to be congratulated on the way in which they have recorded the knowledge they have acquired by experience, and a debt of gratitude is due to the Universities Federation of Animal Welfare for producing this book, which will do so much to make this knowledge readily available to all who use or tend laboratory animals.

J. O. L. KING

MAN-ANIMAL RELATIONSHIPS

Tuberculosis in Animals and Man

A Study in Comparative Pathology. By Prof. John Francis. Pp. xvi+357+40 plates. (London: Cassell and Co., Ltd., 1958.) 105*s.* net.

PROF. FRANCIS has collected within the covers of one volume a vast amount of information on tuberculosis in both animals and man, gleaned from sources in all parts of the world. At this time when the elimination of tuberculosis from cattle in Great Britain is progressing rapidly and the time is within sight when the disease will disappear altogether from our herds, it is helpful to have before one this large volume of information of the disease in other species, including man, since these reservoirs of infection could well prove a menace to the maintenance of disease-free herds.

The earlier chapters of the book, which deal with the pathogenesis and pathology of bovine tuberculosis and the control of this disease in cattle, are by no means outdated by the fact that the disease in cattle may soon disappear from Great Britain; indeed, if it is to be prevented from re-establishing itself among our herds a sound knowledge of its pathology and epidemiology is essential.

Prof. Francis deals with the disease in monkeys, guinea pigs, rabbits, voles, elephants, buffaloes, all farm animals (including poultry, dogs and cats), camels, mink and silver foxes, rats and mice, wild animals, ferrets, hamsters, birds and finally cold-blooded animals. At the end of each section of the book the author presents a complete list of references so that the reader can refer to the origin of information dealing with the disease in each separate species of animals. As most of the information contained in the book is factual and supported by clear references, the work invites little or no challenge of opinion. Even so, where the author does draw deductions from the information which he has gathered together, or offer opinions on the significance of the information available, he does so with commendable restraint and the reader will greatly appreciate the complete and objective impartiality with which the work has been compiled.

Illustrations, though not exceptionally profuse, are clear and truly illustrate what they are intended to portray. The author is to be congratulated on producing a work of the utmost interest and value to all who are interested not only in tuberculosis but also in comparative pathology in its widest sense.

This volume will be widely read and highly appreciated in both medical and veterinary circles throughout the world. HAROLD BURROW

CRYSTAL STRUCTURES

Structure Reports

Edited by A. J. C. Wilson. Vol. 8: 1940–1941. Pp. viii+384. 80 Dutch florins. Vol. 9: 1942–1944. Pp. viii+448. 65 Dutch florins. Vol. 15: 1951. Pp. vii+588. 110 Dutch florins. (Utrecht: N.V. A. Oosthoek's Uitgevers Mij, 1956 and 1957.)

THE possibility of considering more than one volume of "Structure Reports"—intended as an annual reference work—in a single review is proof of the welcome fact that the editors are fulfilling their promise not only to keep the series up to date, but also simultaneously to bridge the gap of the war years. This gap is now happily closed with the appearance of Vol. 8, which contains such classical work as the structure of melamine (in which mathematical refinement techniques now in general use were first introduced), the observation that diffuse scattering is a widespread and informative phenomenon, and the X-ray studies of the phthalocyanines.

In all three volumes, as usual, the coverage is excellent, the format acceptable, and the information admirably distilled. The series now forms an excellent starting-point for the systematic analysis of the fruits of some forty years of international endeavour involving the determination of many hundreds of crystal structures—organic, inorganic and metallic—by a variety of diffraction techniques, supplemented by such structural information as may be obtained from other disciplines like spectroscopy.

Published work has not been abstracted blindly. On the contrary, detailed assessments of each structure have been made, and critical comments are inserted by the editors where they have felt it necessary to do so. This critical analysis of published structures is a particularly valuable feature of the series. The vast amount of calculation necessary to extract the maximum information even from experimental data of only moderate quality makes it virtually certain that many published structures could be made to yield more accurate results than those with which one had to be satisfied before the advent of digital computers. On the other hand, high-speed computation allied with a failure to recognize the limitations of the data themselves merely permits us to reach a wrong answer faster than ever before.

Crystallographers generally are alive both to the potentialities and to the dangers of the present stage of development of the subject, and the standing of the editors in their own field is an adequate guarantee that non-crystallographers using these volumes will have the benefit of a sound assessment of the expanding stream of crystal structure analyses which look so impressive in the learned journals. Pondering the rapid increase in size and complexity of solvable structures, one is reminded of the optimistic advertisement—"the impossible we do at once; miracles take a little longer"; and miracles they truly are, for modern techniques are now carrying us, within the life-time of many of the original pioneers of X-ray crystallography, from the sort of crystals the structures of which a physicist can draw from memory to the sort of molecules which lie near the root of life itself. These volumes provide a worthy record of this continuing advance. It is a pity that their price makes them a luxury when their importance renders them a necessity. H. J. GRENVILLE-WELLS

METABOLISM OF THE NERVOUS SYSTEM

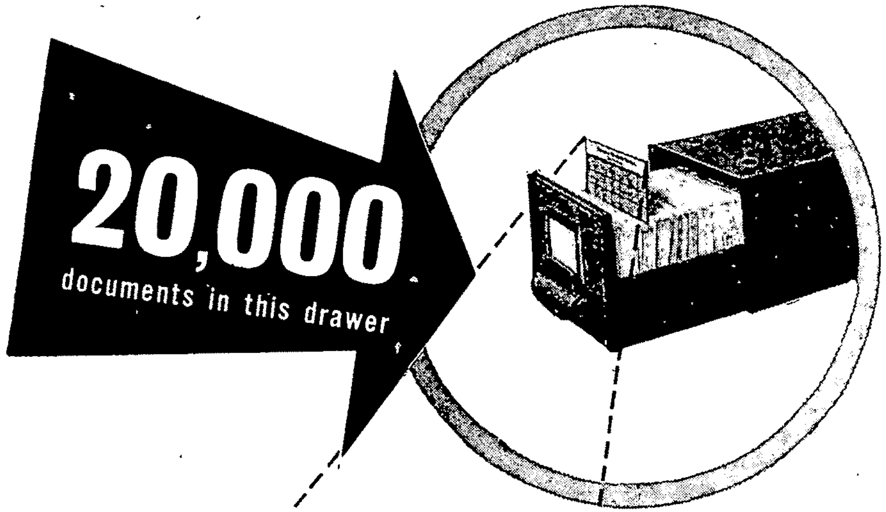
Metabolism of the Nervous System

Edited by Derek Richter. Pp. xiv+600. (London and New York: Pergamon Press, 1957.) 100s.

THE central nervous system provides more fascinating problems than any other part of the body and scientists all over the world are studying it from many points of view and travelling to meetings and symposia and congresses to discuss their results. These discussions often appear in book form and the present work is one of the most valuable of these books. It is based on the Second International Neurochemical Symposium, which was held at Aarhus, Denmark, in July 1956. It is divided into thirteen sections each dealing with a different aspect of the metabolism of the nervous system. Each section opens with a general review, which is followed by shorter and more specialized papers. There is so much that is valuable that it is impossible to mention more than a few examples of interesting contributions. There are some fine reproductions of pictures obtained with the electron microscope, there is a discussion by A. Engström of the use of X-rays to analyse structure, and a discussion of the blood-brain barrier, and various other barriers. R. D. Keynes discusses electrolytes, F. Brink discusses nerve metabolism, S. S. Kety discusses the metabolism of the brain as a whole and J. H. Quastel discusses the metabolism of tissue preparations of brain. O. H. Lowry describes experiments in which he dissects out single cells, weighs them and measures enzymes in them. As the total weight is often less than 0·01 μgm. this requires a rather special balance, but he hopes to extend his technique to single mitochondria.

R. V. Coxon, R. J. Rossiter, L. Einarson and H. Waelsch discuss the metabolism of carbohydrates, fats, nucleic acids and proteins respectively. W. Feldberg discusses acetylcholine, U.S. v. Euler and M. Vogt discuss noradrenaline, S. Udenfriend discusses 5-hydroxytryptamine and J. Crossland discusses all the other active substances which might possibly act as chemical transmitters.

It will be seen that this book covers a wide field, but only a small proportion of the papers have been mentioned; there are well over fifty altogether. It is a valuable guide to the results obtained by many different methods written by the leading authorities. Many of the papers are followed by short discussions, which help those who were not there to form a judgment of their importance. The book is beautifully produced but expensive. Libraries will have to buy it; individuals working in this field will buy it if they can afford it. J. H. GADDUM



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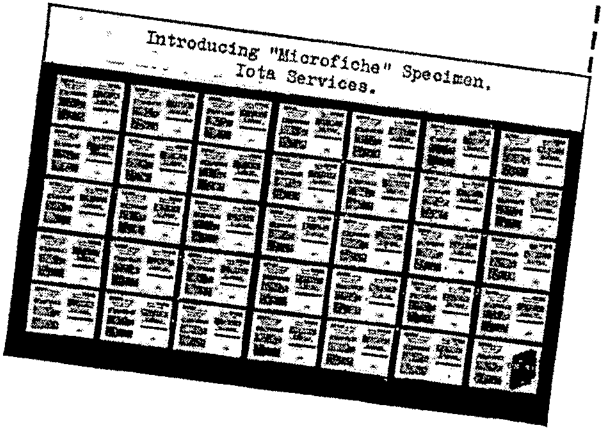

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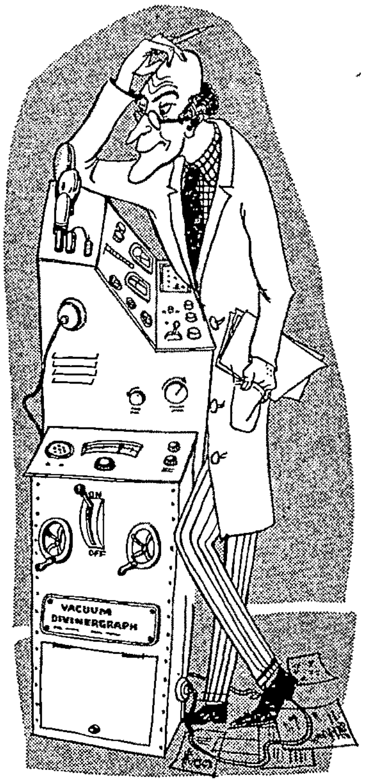

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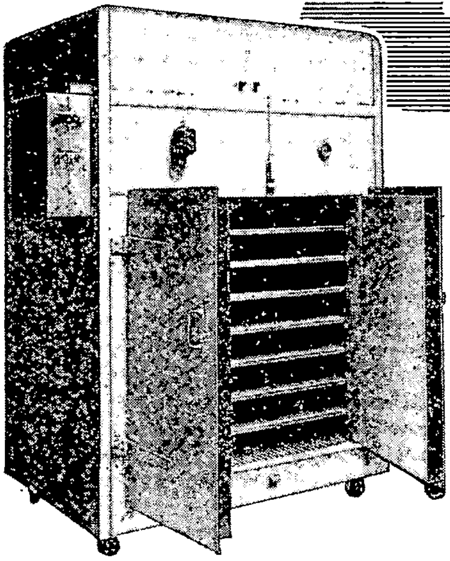

AN INTERNATIONAL MILK TEETH RADIATION CENSUS

By Dr. HERMAN M. KALCKAR*

U.S. Department of Health, Education, and Welfare, Public Health Service, National Institutes of Health, National Institute of Arthritis and Metabolic Diseases, Bethesda, Maryland

WITHOUT expressing here any opinion concerning atomic weapons test programmes, I wish to suggest a scientific study which would at the same time have educational values in its practical demonstration of the peaceful applications of atomic research. The suggestion arises from the belief that any family, regardless of whether or not its country has ambitions in the development of atomic weapons, would be sympathetic to and support an international study involving atomic radiation and ultimately concerned with the health of its own children.

It is generally recognized that young children take up radioactive strontium and cæsium more intensely than adolescents and adults. It is most likely that they also have higher biological radiosensitivity, regardless of whether the dosage results from radioactive strontium, cæsium, iodine, or X-rays. Hence radiation hazards, both those stemming from the peaceful use of atomic power and those having to do with the military use of nuclear energy, must be recognized as being greater during early childhood. Moreover, modern biology has demonstrated the incidence in various human races of certain aberrations, such as defects in reductive metabolism. These considerations, together with the great need for precise knowledge of the biological factors involved, should be stressed to the general public and to all those whose informed participation would be essential to the success of the project to be described.

The official public health agencies of every nation, and especially of the British Commonwealth, China, India, the United States and the U.S.S.R., should organize a large-scale collection of milk teeth (with dates of appearance and shedding, and the child's age in each instance) and conduct measurements of radioactivity on this material. Thousands of countings, performed on a decentralized basis in individual communities and collected on a national basis, would be essential, both to ensure the validity of the results and to assure a widespread sense of active participation on the part of the people of many nations.

Such an International Milk Teeth Radiation Census would contribute important information concerning the amount and kind of radiation received by the most sensitive section of any population, namely, the children. At present, important although rather erratic data exist, based on autopsy of bone samples derived mainly from adults. If a study of a large-scale collection of deciduous teeth were to be initiated in order to confirm and extend these data, it would require an extensive technical organization, adequate equipment, and trained personnel.

Early work by Hevesy, Holst and Krogh[1], Armstrong[2] and Pedersen and Schmidt-Nielsen[3] made it clear that dental enamel takes up phosphorus-32 rapidly during its formation but does not significantly renew itself; dentine renews itself to a detectable degree but much more slowly than bone. Dr. Wallace Armstrong, University of Minnesota, and Dr. S. Kreshover, National Institute of Dental Research, directed my attention to the fact that measurements of radiation from deciduous incisor teeth would reflect the situation as it existed about seven years previously, namely, at birth or shortly before, when the calcified structure of the deciduous teeth is deposited. At present it would seem necessary to pool several deciduous teeth in order to acquire sufficient material.

The proposed milk teeth census is, of course, a long-range programme. If a continued general trend toward a rise in radioactivity in children's teeth were ascertained, it might well have important bearings on national and international policy. The results should be conveyed to the public without interpretations which might give rise to either complacency or fear, but rather in a spirit that would encourage sober, continued, active concern. It should be emphasized that the data would portray the situation as it existed about seven years previous to the study. In spite of this, the fact that these data would give a general estimate of the exposure of newborn children to radioactivity should be stressed.

Measures to keep the radioactivity of teeth and bone structure at low values, especially in young children, should—in accordance with the results of the study—be initiated with full public explanation, emphasizing the limitations of such measures. In connexion with the diet, the increasing use of soybean milk, especially in the Orient, would make it of interest to compare the radioactivity in milk teeth of children reared on soybean milk with that of children drinking cow's milk. The former might be less radioactive because the added calcium stems from rock which represents ancient deposits that have not been in contact with radioactive fall-out. However, the calcium present in the soybean itself may actually exceed that of dairy milk with respect to concentration of strontium-90. An appreciable group of children inhabiting the Pacific islands and Japan derive their calcium intake from fish-bones which might be relatively high in strontium-90, although the dilution factors of the ocean may tend to produce lower values.

It would be most effective if the International Milk Teeth Radiation Census could be carried out simultaneously, or nearly so, throughout the world. The United Nations might be the best agency to handle such a project. It would be particularly impressive if the Western world—which has contributed so greatly to the development of ingenious tools for the peaceful use of atomic energy—took the initiative by offering to make its equipment and technical advice available to any country interested in participation in this project. India, for example, would be uniquely equipped to give impetus to the study in the Orient, both as a direct participant and as a means for contact with China and other countries of the Far East which would have much to contribute.

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* Present address: School of Biology, Johns Hopkins University.

In another continent, the Scandinavian countries, and notably Denmark, might be in a position to play a comparable part. Such a concrete demonstration of respect and reverence for life, regardless of creed, colour, or political system, might well contribute to a growing feeling of confidence among nations, and a special confidence in those nations which might elect to give initiative to or participate in a world-wide study of this kind.

It is a pleasure to express my gratitude to Dr. Warren Weaver, vice-president of the Rockefeller Foundation, for his kind interest and encouragement and for his valuable advice during the formulation of this article.

[1] Hevesy, G., Holst, J. J., and Krogh, A., *Kgl. Dan. Vidensk. Selsk. Biol. Medd.*, **13**, 1 (1937).

[2] Armstrong, W. D., "Ann. Review of Biochem.", **21**, 415 (1942).

[3] Pedersen, P. O., and Schmidt-Nielsen, B., *Schweiz Monatsschrift Zahnheilk*, **51**, 647 (1941); *Acta Odontol Scand.*, **4**, 1 (1942).

THE INTERNATIONAL SCIENCE HALL AT THE BRUSSELS EXHIBITION

THE exhibition in the International Science Hall at the Brussels Universal and International Exhibition is designed to show the aims, methods, and results of pure scientific research in the fundamental sciences, with a special emphasis on developments since the last World Exhibition was held in New York in 1939. The exhibits are restricted to four main topics of research—the atom, the crystal, the molecule and the living cell—and are arranged in the main body of the hall in four overlapping sections, one for each of these subjects. The growth of science from the earliest times to the present day is illustrated in the entrance hall.

The scope of the exhibition is perhaps best indicated briefly by a list of the headings under which the exhibits are described in the catalogue. In "The Atom" section these are: atoms and nuclei, isotopes, radioactivity, neutrons and fission, nuclear reactors, accelerating machines, elementary particles, cosmic rays, cloud and bubble chambers and nuclear plates, solar energy and thermonuclear reactions. In "The Crystal" section they are: the crystal lattice and lattice defects, the determination of crystal structures, crystal growth, dislocations and diffusion, phase changes, mechanical properties, electrical and magnetic properties, optical properties and crystal surfaces. In "The Molecule" section the main headings are: chemical bonds, molecular energy states, structural properties, techniques of separation (including thermodiffusion and chromatography), catalysis and kinetics, surface phenomena, colloids, radiochemistry, general chemistry and macromolecules. Finally, in "The Living Cell" section, the exhibits are concerned with the chemical constituents of cells, genetics, radiobiology, viruses, bacteriophage and bacteria, protozoa and fungi, photosynthesis and vegetable cells, animal cells and embryology.

The idea of staging an international exhibition of pure science as part of the Brussels Exhibition was due entirely to the Belgians, who have also provided the hall, the essential organization and a large number of the exhibits. Fourteen other countries, Austria, Czechoslovakia, the Federal German Republic, France, Holland, Israel, Italy, Portugal, Spain, Switzerland, the United Kingdom, the U.S.A., the U.S.S.R. and Yugoslavia, have also contributed to it. The overall plans were made by a committee of scientists from all the participating countries under the chairmanship of Prof. Robert van Cauwenberghe, and the exhibits were selected and co-ordinated by four sub-committees with the Belgian scientists, Profs. M. de Hemptinne, W. Dekeyser, G. Smets and P. Bordet, as chairmen respectively for the Atom, Crystal, Molecule and Living Cell sections. The individual exhibits, of which there are about five hundred, have been devised by leading scientists in the contributing countries, generally with the assistance of professional designers.

One of the principal objects of the organizers is to show that pure scientific research is a truly international activity. A great deal has been done, therefore, to avoid attracting attention to the differing nationalities of the contributors and to emphasize the aims and methods they have in common. The exhibits are arranged strictly according to their scientific content without regard for their country of origin; they are more or less uniform in design and the names and countries of the scientists responsible for them are displayed for the most part in an unobtrusive manner. Naturally enough, the exhibits do not all conform exactly to the recommended standard pattern, but there is certainly enough general uniformity of design for the organizers' main aim to be realized, and the few exhibits that are markedly different add a necessary touch of variety to the whole.

It is hoped that all sections of the public will visit and profit by this exhibition, and exhibits have therefore been provided both for laymen and for specialists. In addition, the Belgians have made a special introductory film in which most of the concepts necessary for an understanding of the exhibits are introduced in simple terms for the benefit of visiting non-scientists. This film is shown at regular intervals during the day in a special cinema inside the hall, every seat of which is equipped with ear-phones on which the film commentary can be heard in any one of the five languages, French, Flemish, English, German and Spanish. There are two smaller cinemas in which programmes of the best scientific films made by all the contributing countries are shown.

The exhibits in the hall are of three main types. Those of the first kind are intended to supplement the film in introducing the fundamental ideas and principal experimental techniques of modern research to visitors with little or no scientific training. These exhibits include, for example, atomic models, explanatory models of instruments such as the cyclotron, a demonstration of diffraction phenomena and their use in crystal structure analysis, an explanation of chemical bonding and an account of the Mendelian laws of heredity vividly illustrated in a collection of birds and animals. The exhibits of the second type are historical and show by means of original documents and models and replicas of famous apparatus the development of important experimental techniques and the performance and significance of crucial experiments. Among them may be noted the account of Becquerel's discovery of radioactivity in uranium, a model of the laboratory in Cambridge where Cockcroft and Walton first split the atom without the use of natural radioactivity, and a replica of the remarkably simple apparatus with which Hahn and Strassmann first recognized nuclear fission.

The remaining exhibits, those of the third type, which far outnumber the rest, are concerned with the methods and results of the latest research. They include a great deal of working apparatus—in the Atom section, for example, there are two working nuclear reactors—and many of them are concerned with quite advanced ideas. The general level of difficulty in fact approaches that of the exhibits at a Royal Society conversazione. It is scarcely fair to single out any of these exhibits for special attention, but some account of the Russian exhibits may interest the many people who are unlikely ever to visit the U.S.S.R., and it will also serve to indicate the standard attained by the exhibits in general. They are characterized by large frameworks standing on illuminated bases of metal and glass and carrying diagrams and models in fluorescent paint and neon lights which illustrate the subject of the exhibit. These centre-pieces are designed to attract attention to the exhibits, the serious contents of which generally consist of the latest apparatus, usually in working order and operated by a resident staff of scientists and technicians, and accounts of the results obtained by its use. Thus in the Crystal section the Russian exhibit on crystal structure determination by means of X-ray and electron diffraction consists of an array of crystal structure models mounted on a characteristic centre-piece, alongside an elegant apparatus for electron diffraction studies of single crystals from the Crystallographic Institute of the Academy of Sciences in Moscow. In the Molecule section the exhibit on chain reactions by Prof. N. N. Semenov, who shared with Sir Cyril Hinshelwood the 1956 Nobel Prize for Chemistry, has for its central feature an elaborate panel in which the course of various reactions is illustrated by means of automatically controlled lights. This is surrounded by apparatus used in the study of such reactions, including a mass-spectrograph for the study of free radicals, a high-speed camera for the study of explosions and an apparatus for the study of reactions under high pressures.

The British contribution of more than fifty exhibits in all parts of the hall was organized by Sir Lawrence Bragg, at the Royal Institution, with the special co-operation of Prof. C. F. Powell and the United Kingdom Atomic Energy Authority in the Atom section, Prof. E. R. H. Jones in the Molecule section, and Prof. Alex. Haddow in the Living Cell section. The individual exhibits were arranged by scientists throughout the country with the help of many university and government laboratories and industrial organizations. Most of them were designed in general accordance with the standards recommended by Gunther Hoffstead.

The British exhibits in the Atom section include models of the Cockcroft–Walton laboratory, the 7-GeV. proton accelerator now being built at Harwell and the Harwell tandem generator. They also include a modern mass-spectrometer shown in comparison with a replica of the 1937 Aston mass-spectrograph from the Cavendish Laboratory, and an exhibit illustrating the discovery of mesons in cosmic rays. In the Crystal section they include accounts of the structures of collagen, deoxyribonucleic acid and vitamin B_{12}, determined by the methods of X-ray crystallography, together with a description of the tertiary structure of the protein myoglobin, also determined very recently by these methods. Also included are exhibits on neutron diffraction investigations, the growth of crystals and the nature of crystal surfaces and dislocations as they are observed directly by electron microscopy. In the Molecule section they illustrate polar molecules, electron magnetic resonance, chromatography, insulin, vitamin B_{12} again, reaction kinetics, conformational analysis and radiochemistry. The British exhibits in the Living Cell section include accounts of proteins, cell division, 'lamp brush' chromosomes, the human chromosome number, the function of deoxyribonucleic acid, radiobiology, the structure of viruses, the malaria parasite, the mechanism of muscle contraction, the fine structure of *Amoeba proteus* and the effects of vitamin A on cells grown in tissue culture. The film programmes shown daily in the small cinemas include a high proportion of British films on loan for the duration of the exhibition from a number of laboratories, film libraries and film makers.

The International Science Hall has now been open to the public rather more than two months and a large number of people have visited it. Many of them agree that although it is more than usually successful in presenting science at a popular level, it is most successful as a science exhibition for scientists. Visitors who have had no scientific training are often overawed by the scope and complexity of the exhibits, despite the many ingenious efforts that have been made to explain them. The people likely to profit most from visiting the Science Hall are undergraduate scientists and specialists, who will find there a review of the latest research in physics, chemistry and biology provided by leading authorities in each subject, and also a striking demonstration that science is best learned as a whole rather than divided into separate subjects that become increasingly less self-contained as knowledge advances. The exhibition closes on October 19.

D. C. PHILLIPS

ANTARCTIC RESEARCH

THE idea of holding an informal symposium on Antarctic research in New Zealand during February 1958, following the relief of Antarctic stations, was first discussed by the members of the United States and New Zealand National Committees for the International Geophysical Year. Conceived as a meeting between American and New Zealand field scientists, its scope was broadened at the 1957 Paris conference to include all nations with a working interest in the Antarctic. The confluence of several expeditions at Wellington was rather demanding in view of the exigencies of Antarctic operations but, through the goodwill of all and some sacrifice on the part of many, about seventy scientists from

Australia, France, Great Britain, New Zealand, South Africa, the United States and the U.S.S.R. were able to attend the meetings held in Wellington during February 18–22.

The participants were welcomed to New Zealand by the Prime Minister (the Right Hon. Walter Nash, P.C.) at a morning reception. Mr. Nash expressed the hope that future Antarctic research would take place "in the spirit of the International Geophysical Year". Business meetings of two types were arranged: the general meeting, at which informal papers would be presented; and the discussion meeting, mainly confined to the round-table conference of specialists. A considerable number of visiting and New Zealand scientists attended the latter meetings to listen to the discussions. Each meeting was presided over by a worker in the subject, and because of the informal nature of the symposium no attempt will be made to present the full proceedings.

The first meeting, devoted to "Special Investigations in Glaciology", had as its chairman Dr. J. Zumberge (United States). So much material was available on this subject that a whole day was devoted to it. Dr. T. Pewe (United States) outlined his summer's work on the glaciological history of McMurdo Sound, mourning the fact that the terminal moraines, from which a good deal of the history can be read, lie on the sea-bottom. Apart from two late Pleistocene glacial advances, there is evidence of a much older and more extensive advance of the Antarctic ice cap into McMurdo Sound, which covered all the valleys in the area and filled the Sound itself with glacier ice. Questions concerning the synchronism of Antarctic glacial cycles with other regions will probably best be answered by carbon dating of the samples collected from the deltaic beds in the ponds of the Ferrar and Koettlitz Glaciers. Periglacial processes on Antarctic rocks between 50° E. and 170° E. were described by Prof. K. K. Maarkov (U.S.S.R.). The physical and chemical weathering processes are similar to areas such as the cold, highland deserts of Asia as well as northern and western Greenland, the dominant factors being long duration of solar radiation, low humidity and low temperatures. Solifluction is observed but is feeble. The techniques of obtaining ice cores, developed in Greenland, were applied to a borehole at Byrd Station, which reached a depth of 1,013 ft. The Failing 1500 rig was operated by three men and 98 per cent of core was recovered, a remarkable achievement. The bottom layer is of the order of 700 years old, there being an average annual accumulation of 20 cm. water equivalent. E. W. Marshall (United States), after describing these efforts, gave a detailed list of temperatures and densities. More primitive methods were used by R. Cameron (United States) at an inland base 50 miles from Wilkes Station, where a pit 2 m. square was dug to a depth of 35 m., an auger hole being drilled a further 27 m. Stratigraphy, density and sastrugi patterns were investigated. At a depth of 33 m. a tunnel 2 m. in diameter and 6 m. long was excavated to study deformation. The average annual accumulation was 15 cm. water equivalent. A comprehensive account of the detailed Soviet studies on the movement, mass economy, heat balance, temperature regime, form and thickness, snow cover and alimentation of the Antarctic ice sheet was given by Prof. P. A. Shoumsky (U.S.S.R.). The east Antarctic ice sheet has a complex irregular form conditioned by sub-glacial relief; on the whole, it probably approximates to a flattened ellipse with irregularities introduced by the topography of the bedrock.

Deformation of the Ross Ice Shelf produced by the presence of Roosevelt Island was the subject of a special study by a team led by Dr. J. Zumberge. An extensive grid was surveyed during the past summer, and by repeating the survey in the summer of 1958–59 it is hoped to measure the rate of strain in various directions. Use was also made of dial strain gauges to measure the change in width of crevasses. Ice structures resulting from compression, tension and shear are all present in the area. The Ross Ice Shelf is between 230 and 290 m. thick around Little America, 300 m. thick off Minna Bluff and 420 m. thick near the Beardmore Glacier, being still afloat in the latter position, according to H. Bennett (United States), a member of the Ross Ice Shelf traverse party which covered 1,440 miles over the Shelf during the past summer. Seismic shots every 30 miles were supplemented by gravity and magnetic observations and glaciological pit work. The thickness of the ice and the depth of the bottom of the Ross Sea were obtained by using the measured travel-time for reflexion from the sea bottom and assumed velocities for ice and water.

B. Imbert (France) was chairman at the second meeting, on "The Topography of the Sub-Glacial Continent". At this meeting the provisional results of all traverses except that of the United States party to the Weddell Sea were presented and techniques discussed, even though at the time of the symposium some traverses were not quite completed (Fig. 1). Considerable geographical discoveries were made by the Byrd Station traverse party and during the support and reconnaissance flights. From the Ross Ice Shelf–Rockefeller Plateau boundary to the end of leg 1 (76° 30′ S., 113° W.) the ice–rock interface is rough, the thickness of the ice varying between 600 and 2,700 m.; all but a few peaks of the rock floor are

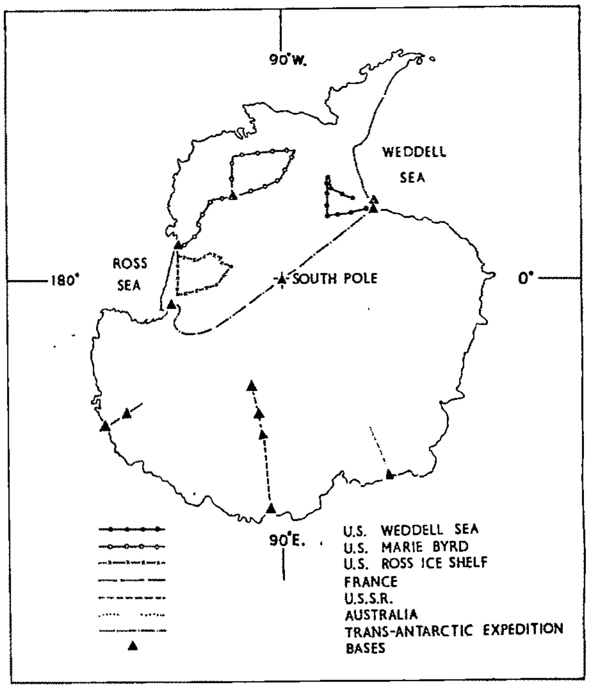

Fig. 1. Antarctica, showing major scientific traverse routes (1957–58)

at present below sea-level, the major portion far enough below to be under water if the ice were removed and the land allowed to rise into isostatic balance. Leg 2 shows quite a different picture, with a smooth bottom, great thickness of ice (from 2,300 to more than 3,500 m.), and broad gravity anomalies. Near the middle of the leg the rock floor reaches a depth of 2,000 m. below sea-level at a point where the elevation of the surface is a little more than 1,500 m. Leg 3, south-west from the Sentinels (77° 30′ S., 89° W.) was in a still different type of area—the rock floor being very rough and mostly above sea-level, breaking the ice surface in several places to form nunataks. This evidence indicates, subject to further examination of rock samples, that the Sentinels structure extends south-west at least as far as 80° 30′ S., 98° W.

The results of the Soviet, Australian and French radial profiles in East Antarctica showed some similarity, that is, complexity of land topography, mainly above sea-level except near the coast, but with great thicknesses of ice as high altitudes were reached. Dr. F. Jacka (Australia) noted the successful use by the Australians of a powered auger which enabled them to lay charges at depths of 30 m. There was agreement among all speakers that a small charge detonated at as great a depth as possible contributed greatly to good seismic records. G. Pratt, seismologist with the Trans-Antarctic Expedition, forwarded his preliminary results from Southice to Midway depot (81° 30′ S., 146° 09′ E.). On the Weddell Sea side of the South Pole the land surface is typically 1,000–3,000 ft. above sea-level and probably never below it ; several ridges rise to a maximum of 7,000 ft. Twenty-five miles either side of the Pole the ice is very much thinner than at the Pole itself, and on the Ross Sea side remains thin, occasional crevassed areas being apparently on top of peaks covered by only 1,000 ft. of ice. The seismic results are generally confirmed by gravimetric data, but inaccuracies of the free air corrections weakens this support. American traverse parties endeavoured to minimize the effect of changing atmospheric pressures on elevations by leap-frogging. Considerable interest was shown in the experiences of the airborne seismic and glaciological unit under Dr. J. C. Cook (United States) operating from McMurdo Sound. Seismic soundings, gravity readings and glaciological studies were made at three stations on the plateau west of the Royal Society Range. At one of these stations the aircraft remained on the ground, while at the other stations the aircraft returned to base during observations. The seismic soundings were not very successful. Gravity deficiencies of more than 100 mgal. below McMurdo pendulum station were obtained, assuming ice to sea-level. A negative anomaly of similar magnitude is reported from the South Pole.

Dr. H. van Loon (South Africa) took the chair at the session on "Meteorology", which was opened by R. Taylor (United States) with an account of the work of Weather Central and the complex communication and reporting network which supplies information to Little America. Commander J. Mirabito (United States) recalled the great difficulties of operational forecasting in the Antarctic during 'Deepfreeze' I and II before the reporting network got into stride, when long-range flights were made on forecasts using data from McMurdo Sound supported by a few scattered ships. Air operations, however, have never been hampered by strong winds, and Commander Mirabito could only recall one incident involving aircraft icing during polar flights. I. Kerr (New Zealand) pointed out that with the present reporting network, Antarctic weather data are available to mid-latitude forecasters, but so far they have made little improvement in the effectiveness of New Zealand forecasting. Any improvement would be through a better knowledge of general atmospheric circulation and processes resulting from Antarctic studies. In common with other meteorologists in the southern hemisphere, he emphasized the large oceanic gaps in reporting centres, which only weather ships could fill. Forecasting of gales at a station where synoptic data were not available was discussed by Dr. J. Shear (United States). Changes in pressure were of little use, and though cloud sequences were classical and informative, Shear found that the most effective tool was a 'time-hodograph' of the wind vector at the 500-mb. level.

Soviet aerologists led by Dr. O. Krichek considered that the configuration of the Antarctic continent and particularly its northward extensions was responsible for six regions of stable high-pressure tongues. Reinforcement of these tongues blocks cyclones over the adjoining seas, and zones of stationary cyclones between these ridges occur in the Weddell Sea, off eastern Queen Maud Land, Mackenzie Sea, off Wilkes and George V Land, and in the Ross Sea. Ridges of the Antarctic anticyclones may connect with subtropical anticyclones, inhibiting zonal circulation, which is by no means exclusively typical in the southern hemisphere. Aerial reconnaissance for ice over the Davis Sea confirms that the cyclonic zones have a substantial effect on the position of the ice belt. At Mirny during the winter, inversions of up to 35° C. were recorded and often persisted, though down-slope winds reached a velocity of 40 m./sec.

Prof. H. Hoinkes (United States), who was chairman of the session on "Radiation", discussed the heat balance equation at Little America. He carefully measured or assessed the various factors: radiation balance, turbulent exchange, latent heat change, precipitation exchange and conduction from below. Latent heat, precipitation exchanges and conduction from below are not significant. Winds and temperatures measured at several levels up to a height of 17 m. show that turbulent exchanges are rarely of much importance at Little America. Thus, radiation balance is the only important term in the equation and this was studied with a Link–Fuessner solarimeter, Schultze net radiometer and an Ångström pyrgeometer. The lowest outgoing radiation recorded was 0·08 langley/min., but only occasionally was 0·06 langley/min. exceeded. Inversion in the presence of clear skies would decrease this to 0·02 langley/min. Summer albedos were remarkably high. At the South Pole the mean of 100 readings was 0·89 (range, 0·845–0·943) ; at Byrd Station 0·88, and at Little America 0·90 after fresh snow.

A unique and important part of the Soviet radiation programme, described by Dr. V. I. Shliakhov, was the measurement of the short-wave radiation balance at various altitudes. Special flights were made for this purpose. The great transparency of the Antarctic atmosphere undoubtedly accounts for the very low linear gradient of 0·0004 langley/min. per 100 m. up to 4,500 m. The figure for medium latitudes in Europe is 0·03–0·04 langley/min. per 100 m. The instrumental diversity in measurements of radiation made at Antarctic stations was very apparent in discussion. Shliakhov used a Yanishevsky balance meter and attempted to protect it from wind and snow damage by shielding it with a polyethylene cover 20 μ thick. A minor parlour game was played of deriving the minimum possible surface temperature in Antarctic regions. Shliakhov gave − 80° C. ± 2° C., while Taylor preferred − 78° C. The lowest surface temperature recorded at the South Pole station during 1957 was − 74° C.

The chair for the session on "Oceanography" was taken by R. M. Cassie (New Zealand). The presence of the Soviet research ship *Ob* in Wellington during the symposium ensured a strong representation of Russian marine scientists. An account of the first two Antarctic cruises of *Ob* (1956 and 1957) was given by Prof. V. Kort. During these two cruises 329 oceanographic and 225 geological stations were occupied, mainly in the Indian sector of Antarctica. About 150 cores 2·0–5·5 m. long have been taken by a gravitator tube, and five cores of 16 m. have been taken by a piston corer. The present cruise is charged with similar investigations in the Pacific sector of Antarctic waters. From continuous echo soundings and cores, Dr. A. V. Jivago (U.S.S.R.) was able to discuss the types of bottom relief in the southern Indian Ocean and east Antarctic seas. Extremely complicated volcanic relief covers approximately two-thirds of the area explored. Besides the known volcanic chains extending from the Atlantic Ocean across the Crose plateau to the Kerguelen–Gauss range, big sub-surface volcanoes have been discovered to the west of Heard Island and north-west of the Prince Edward Islands. Their relative heights reach 3,000 m. Vast areas consist of lava plains with stepping, hilly and block surfaces. The Antarctic Shelf, which represents the most complicated type of relief, was investigated in more detail. Its boundary is considerably deeper than other continents (500 m. or more), the surface is often rough and in some places devoid of covering sediment. Several morphological sub-types have been distinguished within the Shelf limits.

According to Dr. A. P. Andriashev (U.S.S.R.), who described the ichthyological investigations of *Ob*, 1,100 specimens representing 75 species and 16 families have been caught. In the shallow water of the eastern Antarctic continent, trematoms and *Gymnodraco acuticeps* are the most abundant species, and some of these, especially *T. bernacchi*, may have some fishing importance to wintering-over parties. New types of chænichthyid and harpagiferid fishes were found among fishes caught by trawls at depths between 100 and 3,000 m. Eight more species of the white-blooded chænichthyidae were added to the five already known. Qualitative investigations of the bottom and plankton invertebrates have shown the extremely low productivity of food forms (for fishes) of the bottom fauna, in comparison with the rich development of the pelagic crustaceans, substantiating Nybelin's hypothesis concerning the cause of partial transition of many bottom notothenioid fishes to pelagic feeding habits. The factors governing the character of bottom fauna of the shelf are the great depth of the boundary, complicated relief, extremely poor sorting of bottom sediments, and strong bottom currents which carry the subsiding detritus away to the ocean. Consequently, an extremely rich and varied fauna of sponges, cœlenterates, bryozoans, brachiopods, ascidians and an impoverished fauna of crustaceans and molluscs are characteristic of the Shelf. One of the main differences between the Shelf faunas of Antarctica and that of other areas is that the polymixtous nature of the former makes it very difficult to ascertain the leading species.

Dr. R. W. Burling (New Zealand) exhibited a vertical section of isotherms south of New Zealand, in which tongues of cold water are present in positions suggesting the existence of a large horizontal eddy. Such eddies would have a great influence on mixing between various water masses in their predominantly eastward flow. The theoretical model of the Antarctic circumpolar current propounded by Hidaka and Tsuchiya, in fact, requires an occurrence of such eddies.

Dr. T. Hatherton (New Zealand) was chairman of the session on "Seismology". Epicentres within the Antarctic area were reported only by Scott Base (including tremors from Erebus) and Halley Bay, although stations along the coast of East Antarctica report a plenitude of seisms from the Indian Antarctic swell. Both d'Urville and particularly Scott Base reported remarkable changes in microseismic activity, very low in winter, very high in summer, presumably related to the effect of pack ice on the generation or transmission of microseismic energy. The successful operation of seismographs on floating ice (Halley Bay) and inland *névé* (South Pole and Byrd) was of considerable interest.

The chair for the meeting devoted to "Biology" was taken by Dr. R. A. Falla (New Zealand). Observations made on the Byrd traverse were summarized by Dr. D. Hale (United States). Eleven snow petrels and twelve skua gulls were sighted at distances more than 300 miles from the coast. A penguin track was discovered at 77½° S., 99° W. at an altitude of 1,260 m. The track was followed for more than a mile and traces of urine and fæces obtained. More than sixty specimens of lichens were collected; the entire collection with possibly two exceptions seems to be composed of species previously undescribed. *Umbelicaria* is noticeably absent and there is no *Usnea* sp., which is present all along the coast of Antarctica. *Lecedia* sp. and *Buellia* sp. predominate, as might be expected, and *Alectoria* sp. seems fairly widespread. In the Sentinel Mountains area individual nunataks, though fairly close in location, may have rather different floras. Flora affinities seem to be with the lichens of the west coast rather than with those of the Edsel Ford Mountains.

Dr. K. A. Brodsky (U.S.S.R.) has examined the mass development of phytoplankton in the cold waters near the continent, and along sections on the 90° E. and 78° E. meridians, with the northern boundary near 63° S. Zooplankton was poor in waters rich with phytoplankton, but increased to the north. The biomass in the northern regions did not exceed 0·75 gm./m.^{3}, whereas in the phytoplankton zone there was not less than 1 gm./m.^{3}, sometimes reaching more than 7 gm./m.^{3}. In Antarctic waters the cold intermediate layer is not impoverished, but is somewhat richer in plankton than the superficial one. Brodsky considers that the term 'Sub-Antarctic', like 'Sub-Arctic', should be discarded for biogeographical purposes. He prefers a subdivision into 'Antarctic' (northern boundary between 60° S. and 52° S. for different areas), 'Notal' (northern boundary between 50° S. and 40° S.) and 'Tropical'. Brodsky proposes using the composition and distribution of the Celanoid to compare the biogeographical regions of both hemispheres. Data on bird-banding, seal-branding and other studies were exchanged, and

Pewe reported the discovery of 81 carcasses of crabeater seals at altitudes of 1,000–2,000 ft. in the foothills of the Prince Albert Mountains.

Dr. F. Jacka (Australia) occupied the chair at the session on "Aurora". Interest centred mainly on radio echoes and the problem of relating them to visually observed auroras. At Invercargill, all-sky camera and very high-frequency radio-echo equipment have been run continuously. M. Gadsden's (New Zealand) analysis of six months results showed that the probability of aurora being present at the same time as radio echoes increases with increase in local K-index, suggesting that there is no intimate connexion between visual aurora and radio echoes. Radio echoes show a broad maximum in occurrence at local midnight (35 per cent) and a minimum shortly before local noon (3 per cent), whereas no significant diurnal variation has been detected in the occurrence of visual auroras. The echoing region heights average 110 km. and, with the radar looking south, radial velocities are generally inward (that is, northward) before local midnight and outward (southward) after, with an average north/south radial velocity of 400 m./sec. K. Bullough's (France) measurements at d'Urville (geomagnetic latitude 75·5° S.) showed that diurnal distribution of echoes displays a very sharp peak in the evening in winter with more even occurrence throughout the day in summer. The echoes occur almost entirely to the north during the winter months, with a marked increase in activity to the south in summer. Skip echoes are believed to have been observed on three occasions. Analysis of the d'Urville results is not yet sufficiently advanced to permit correlation with visual activity. All stations reported little success with spectrographs. Many observers commented upon poor design and engineering features which restricted the operation of their instruments. Little discussion was possible on visual auroral observations at Antarctic stations as the results have not yet been reduced.

The closing session was devoted to "Future Research in the Antarctic", with Dr. G. de Q. Robin (Great Britain) in the chair. Seven speakers discussed future work in their respective fields. Dr. F. Jacka, dealing with the physics of the upper atmosphere, requested more studies of 'whistlers' and the 'dawn chorus', which have hitherto been almost entirely neglected. He also suggested a better geographical distribution of cosmic ray stations, which are at present concentrated around the coast of the African–Australian quadrants. Spectrographic studies of the aurora have been less successful than expected. Simpler instruments with more limited objectives might be preferable for future work. B. Imbert, speaking on ice cover and glacial relief, reviewed the achievements of the past year in seismic sounding, and came to the conclusion that tractor trains with close air support, using mechanized drilling techniques to place a small charge as deep as possible below the surface, form the most desirable unit. The high plateau of east Antarctica offers the severest challenge. There was some discussion on the use of radio waves for soundings of the depth of ice, but in the absence of confirmed experiments using these techniques, normal seismic methods must continue to be used. The use of the triangular traverse was urged, as being more informative and easier to support. Prof. Shoumsky, dealing with general glaciological problems, outlined possible future Russian traverses, but urged that attention be paid to general ice regime, heat- and mass-balance as well as to form and dimensions. The morphology of the huge ice streams of the continent is an especially desirable study, but one of considerable difficulty because of the broken and crevassed nature of the boundaries. With regard to meteorology, R. Taylor considered that it is now possible to obtain a reasonable representation of the mean circulation over the Antarctic, but a comprehensive picture of southern hemisphere circulation is impossible in the foreseeable future, because of the lack of information over the southern oceans. He endorsed the use of weather ships, as did many other speakers at the symposium. As a by-product of Antarctic work, he predicted considerable improvement in many instruments. Meteorological flights have not been used as often or extensively as they should. Prof. V. G. Kort summarized comprehensively the needs of oceanographic research over the next ten years. In particular, he pleaded for much more concentrated work in zones of convergence and divergence, and in coastal waters an extension of hydrological work at coastal stations, where remarkably few oceanographic studies are done, and comprehensive studies of the pack ice by monthly flights from coastal bases. Actinometric studies have been successfully carried out this season on *Ob* and offer considerable scope in the future.

Dr. R. A. Falla considered that biological studies in the Antarctic had benefited during the International Geophysical Year although they were not planned explicitly, except in the case of the larger vertebrates, where banding and branding studies had been successfully carried out. Amateur observers could do valuable preliminary studies in biological fields, which could be examined to see where professional studies were required. He cited as an outstanding example the collection of lichens from the Marie Byrd Land mountains by the Byrd traverse party. Intensification of taxonomic, ecological and physiological studies was required. Biological research suffers from inadequate national and international organization, and this must be remedied before Antarctic biological research can achieve the same effectiveness as that in the physical sciences. Falla ended with a plea for the greater participation by mature scientists in expeditions, thus emphasizing a weakness in most British Antarctic teams, which rely unduly on the efforts of young graduates.

Dr. T. Hatherton, speaking on the future of crustal geophysics, emphasized the need for precise levelling to the main inland bases. Antarctic seismic activity appears to be present only in the areas of the Ross and Weddell Seas, and determinations of epicentres require at least two stations. He suggested that such dual stations (less than 100 km. apart) might be useful also for gradient and movement investigations in the upper atmosphere, though Jacka preferred dispersion of the stations in ionosphere studies. Seismic and magnetometer work at sea in the areas of most structural interest were recommended. Geology needs no specific recommendations but should be carried out wherever exposures are available. Dr. Robin closed the meeting by pointing out that the best contribution that scientists attending the symposium could make to future research was to work up their results as soon as possible, before new interests and opportunities arise to distract them from completing their Antarctic work by its final publication.

T. Hatherton

NOMENCLATURE OF ROCK UNITS IN THE ROSS SEA REGION, ANTARCTICA

By Dr. H. J. HARRINGTON
New Zealand Geological Survey

A MEETING of ten British Commonwealth geologists who had worked in Antarctica with the Trans-Antarctic Expedition, the New Zealand Ross Sea Expedition, the New Zealand Geological Survey Expedition and the Falkland Islands Dependencies Survey, was held in Wellington in March to exchange information gathered in recent seasons. It became clear that communication of results is hampered by an almost complete lack of a formal nomenclature for rock units of the Ross Sea–Weddell Sea region, the rocks being described, except in the case of the Beacon Sandstone, as 'the Dolerites' or 'the Schists and Marbles' and so on. A nomenclature for the major regional units was devised at the meeting for use in forthcoming publications and maps and, as there are no international arrangements for this matter, it is set out below with explanatory notes. It should help to prevent the confusion that could arise if different nomenclatures were proposed by geologists of expeditions now scattered in several homelands. In devising it, the meeting had as part of its background a knowledge of some of the recent work by United States and Soviet geologists described at an earlier meeting held in Wellington in February.

Quaternary	Moraines, beaches, etc.
Upper Tertiary and Quaternary	McMurdo Volcanics
? Jurassic or Cretaceous	Ferrar Dolerites
Palæozoic and Mesozoic	Beacon System
Lower Palæozoic or Precambrian	Admiralty Intrusives
Lower Palæozoic or Precambrian	Ross System

McMurdo Volcanics (*Group*). This term is proposed for the volcanic rocks of Quaternary and possibly Upper Tertiary age in the Ross Archipelago and other islands in the Ross Sea, the Balleny Islands and Scott Island, and parts of the coast of Victoria Land. The unnamed volcanic rocks of Marie Byrd Land are tentatively excluded. The name 'Ross Volcanics' is not used, to avoid confusion with the volcanic rocks of James Ross Island (Graham Land).

Ferrar Dolerites (*Group*). Dolerite sills and dykes occurring abundantly in the Beacon Sandstone in the Ferrar Glacier district and other parts of Victoria Land, and also in the Beacon System in Adelie Land, and elsewhere, are called the Ferrar Dolerites. Several geologists at the meeting considered that the dolerites of Adelie Land and elsewhere should be distinguished within the group by regional formation names from the type Ferrar Dolerites (Formation) of Victoria Land.

Beacon System. The Beacon Sandstone was named by Ferrar from its occurrence at Beacon Heights in Victoria Land. Similar sandstone and associated sediments occur widely in far distant regions in Antarctica and have either been called Beacon Sandstone or compared and correlated with it. It was the opinion of the meeting that all occurrences could be classified together as Beacon System, that the type rocks in Victoria Land could be called Beacon Sandstone (Group), and that local group names might be appropriate at present in other regions.

Admiralty Intrusives (*System*). The system consists of pre-Beacon intrusives, predominantly granite and granodiorite, in the Ross System. The type rock is the Tucker Granodiorite (new name) of the Admiralty Mountains in northern Victoria Land. The granitic and granodioritic rocks of the McMurdo Sound region are included, as well as, tentatively, those of Marie Byrd Land.

Ross System. The pre-Beacon sediments and metamorphosed sediments so far described from the Ross Sea region are unnamed marbles, schists and associated rocks occurring in Victoria Land from Terra Nova Bay southwards through the Royal Society Range, the 'slate-greywacke formation of Robertson Bay', and unnamed thick 'greywacke'-type sequences of sandstone and shale in Marie Byrd Land. In addition, occurrences of limestone containing *Archaeocyathinae* are known in the Beardmore Glacier district, and seem to be extensive in the Weddell Sea region.

Recent field work has shown that the Admiralty Mountains of northern Victoria Land consist mainly of an assemblage of quartzose greywacke and argillite, meta-greywacke and meta-argillite, schist and some metamorphosed limestone which is being called Moubray Group (new name) and almost certainly includes the 'slate–greywacke formation of Robertson Bay'. Inspection of aerial photographs shows that this group extends south of the Admiralty Mountains towards Wood Bay and Terra Nova Bay. Farther south, rocks of closely similar lithology are associated with marble and schist in the McMurdo Sound region. It is suggested that all these rocks in Victoria Land may be called Ross System, the type beds being those of the Moubray Group. The rocks of the Ross System in Victoria Land give the impression of being the deposits in a major geosyncline in which the shelf sediments with carbonate rocks were deposited in the McMurdo Sound district and southwards, and the deeper-water sediments with few carbonate rocks were deposited in northern Victoria Land.

The sediments of the Moubray Group strike east-south-east into the Ross Sea and towards the very thick greywacke-type assemblages striking north and north-west of the Edsel Ford and Rockefeller Mountains in Marie Byrd Land. Several geologists at the Wellington meeting considered that this is reasonable evidence for tentatively including the Marie Byrd Land assemblages in the Ross System, though distinguishing them by the names Edsel Ford and Rockefeller Groups. If this is done, the only known pre-Beacon sedimentary rock of the lands surrounding the Ross Sea that is not included in the Ross System is the limestone of the Beardmore Glacier–Weddell Sea region that in at least one place contains *Archaeocyathinae*. It seems that its classification must await further work.

OBITUARY

Prof. J. K. Robertson

JOHN KELLOCK ROBERTSON, professor emeritus of physics in Queen's University, Kingston, Ontario, died suddenly in London on June 24.

Robertson came to Queen's as a lecturer in physics in 1909. He had entered the University of Toronto on a classics scholarship, but took his degree in mathematics and physics and spent two graduate years as demonstrator in physics. Except for two interludes of a year each, he remained at Queen's until his retirement from his posts as professor of physics and head of the Department in 1951. The session of 1912–13 he spent at the Cavendish Laboratory, Cambridge, and as a member of Emmanuel College. During 1933–34, he was a visiting professor at the Imperial College of Science and Technology, London.

As a physicist, Robertson's major interests were in the fields of optics and of X-rays and radiology. His text-book, "Introduction to Physical Optics" (1929), has run through successive editions, as did his "X-Rays and X-Ray Apparatus" (1924) and his "Radiology Physics" (1941).

He was an enthusiastic, patient and lucid teacher. His most distinctive courses of lectures were those which he gave to medical students. He was able to persuade his medical colleagues that the study of physics should be continued through two years, allowing more extensive work than was usual in North American medical schools. He was greatly pleased when the members of the last medical class which he taught made him an honorary life member of the class. His interest in medical physics continued after he gave up teaching, and he was an honorary member of the British Institute of Radiology and of the Association of Hospital Physicists.

He was elected Fellow of the Royal Society of Canada in 1926, was president of Section III in 1942–43 and president of the Society in 1944–45. After his retirement, when he spent at least part of each year in London, he represented the Royal Society of Canada and the National Research Council at a number of international gatherings.

Robertson was a literate physicist with a wide range of interests and friends. He had a talent for explaining physics to the layman ("Atomic Artillery and the Atom Bomb", 1945) and an active interest in literature.

He was a fourth-generation Canadian, born in 1885, in Perth, Ontario, which had begun as a Scots settlement some sixty years earlier. In 1932 he published a charming little book, "Sketches of Tayville", which had appeared earlier in the *Queen's Quarterly*, and which recalled his boyhood in a Scottish-Canadian town.

'J.K.' was a man of warm friendships and strong loyalties. He had a contagious enthusiasm for learning and scholarship. His gallantry turned what might have been a lonely retirement into a lively enjoyment of friendships and intellectual interests. He is gratefully remembered by former students and colleagues, by his brothers in the craft and by many friends on both sides of the Atlantic.

W. A. MACKINTOSH

NEWS and VIEWS

National Standards Laboratory, Sydney: Mr. N. A. Esserman

MR. N. A. ESSERMAN, chief of the Division of Metrology, has been appointed as the first director of the Commonwealth Scientific and Industrial Research Organization, National Standards Laboratory, Sydney. This appointment is one of the first consequences of the recommendations of a committee of the Advisory Council which reported last year on the future development of the National Standards Laboratory. Mr. Esserman was born and educated in Sydney, graduating in science with honours at the University of Sydney in 1916. Following a period during and after the First World War at the Arsenal Branch, London, he returned to Australia to join the Commonwealth Department of Defence, later becoming senior physicist, Munitions Supply Laboratories, at Maribyrnong in 1929, and assistant superintendent of laboratories in 1938. During this time, Mr. Esserman had accumulated a wide experience of metrology and general physical instrumentation and their application in the engineering industries. He was therefore well situated to assume the task of developing the newly created National Standards Laboratory when he was appointed senior officer-in-charge of the Metrology Section in 1939. Mr. Esserman took a major share in piloting this young establishment through the turbulent years of the Second World War. The virile engineering industries which have grown to maturity in Australia in the post-war years owe a great deal to the knowledge and experience which Mr. Esserman brought to his labours at the National Standards Laboratory. He also undertook, during the War, a number of other tasks associated with the general effort of munitions production in Australia. He was a member of the Optical Munitions Panel, the Australian Council for Aeronautics, and the Optical Advisory Panel of the Department of Post-War Reconstruction. Mr. Esserman is an active member of many scientific institutions in Australia, having held office as president of the Royal Society of Victoria, Fellow of the Australian National Research Council, chairman of the New South Wales Division of the Australian Branch of the Institute of Physics, trustee of the Sydney Museum of Applied Arts and Sciences, and member of the Technical Education Advisory Council and the International Committee of Weights and Measures. Mr. Esserman will retain his responsibilities as chief of the Division of Metrology.

Dr. G. H. Briggs

DR. G. H. BRIGGS, who is retiring as chief of the Division of Physics of the National Standards Laboratory, graduated in 1916 at the University of Sydney and was appointed lecturer and later assistant professor of physics at that University. His Ph.D. degree was gained in research in association with

Lord Rutherford at the Cavendish Laboratory. At this time and in subsequent research he made notable contributions in the accurate determination of the fundamental constants of nuclear physics, obtaining his D.Sc. degree in 1937. He joined the National Standards Laboratory of the Commonwealth Scientific and Industrial Research Organization at its inception in 1939, being appointed as officer-in-charge of the Physics Section, which became a Division in 1945. Under Dr. Briggs's guidance the Division has not only established a high reputation for research in the physical sciences but has also been of great assistance to manufacturing industry in Australia during its rapid growth during and after the Second World War. Dr. Briggs was scientific adviser to the Australian delegation to the United Nations Atomic Energy Commission during 1946–47; president of the Australian Branch of the Institute of Physics in 1950; and chairman of the Unesco Australian Committee for Natural Science during 1953–55.

Dr. R. G. Giovanelli

Dr. R. G. Giovanelli, who is to be appointed chief of the Division of Physics of the National Standards Laboratory in succession to Dr. Briggs, graduated in 1937 at the University of Sydney, was Research Fellow at the Commonwealth Solar Observatory, and after a short period on the staff of the Sydney Technical College, spent a year at the National Physical Laboratory, Teddington, before joining Dr. Briggs's staff at the National Standards Laboratory. He received his D.Sc. degree at the University of Sydney in 1950 for his studies on the physics of the solar atmosphere. Dr. Giovanelli is a Fellow of the Royal Astronomical Society, and was awarded the Edgeworth David Medal of the Royal Society of New South Wales in 1949. Dr. Giovanelli's main research interests have been in solar physics, the fine structure of the Sun's outer layers, solar activity and spectra, and the emission of radiation from high-temperature atmospheres.

Director of Fire Research: Mr. D. I. Lawson

Mr. D. I. Lawson, who has been appointed director of fire research of the Joint Fire Research Organization of the Department of Scientific and Industrial Research and the Fire Offices' Committee, is forty-seven. He was born in Sheffield and educated at Woodhouse Grammar School. After taking first-class honours in physics with mathematics at the University of Manchester and obtaining an M.Sc. degree for research in X-ray crystallography, he became a lecturer in physics and telecommunications at Woolwich Polytechnic in 1934. Five years later he became head of the Research Division at Pye, Ltd., of Cambridge. Mr. Lawson joined the Fire Research Station at Boreham Wood, Herts, in June 1948, since when he has specialized in problems of heat transfer and the ignition of materials. Since 1952 he has been assistant director to Mr. S. H. Clarke, whom he succeeded on August 1. Mr. Clarke has been appointed director of the Warren Spring Laboratory of the Department of Scientific and Industrial Research (see *Nature*, 182, 225; 1958), which is being built at Stevenage.

National Science Foundation: Dr. R. M. Robertson

Dr. Randal M. Robertson, who has been appointed to the staff of the National Science Foundation as assistant director for mathematical, physical and engineering sciences, was born in Tampa, Florida, and graduated in mathematics and natural philosophy at the University of Glasgow and received a Ph.D. in physics from the Massachusetts Institute of Technology. He taught briefly at both institutions before serving as a research assistant at Columbia University. During 1937–42 he was a research associate with the Norton Company in Worcester, Massachusetts. During 1942–46 he was on the staff of the Radiation Laboratory at the Massachusetts Institute of Technology. In 1946 he went to Washington as head of the Mechanics and Materials Branch of the Office of Naval Research. In 1948 he became director of the Physical Sciences Division, and has been director of the Research Group since 1952. He has conducted research on arc-cathode phenomena; nuclear magnetic moments; physics of solid materials, especially abrasives and refractories; and microwave linear-array scanning antennæ.

British Scientific Attaché in Moscow

In reply to further questions in the House of Commons on July 1 regarding the grading of the post of British Scientific Attaché in Moscow as principal scientific officer instead of deputy chief scientific officer as in Washington, Mr. H. Nicholls, Parliamentary Secretary to the Minister of Works, as representing the Lord President of the Council, repeated what was said on June 17 and 24, namely, that if a suitable candidate could not be found, the grading would be reconsidered. There was no question of wanting to have a higher grade officer in the United States than in Moscow. The immense interchange of knowledge with the United States has justified the team of men with the higher grade there, and when there is any likelihood of getting the same co-operation in Moscow the matter will be reconsidered. Appointment of a higher grade scientist was not excluded; but in opening the new service, the manner of approach rather than scientific qualifications was the more important.

Plutonium from Civil Nuclear Power Stations

An adjournment debate in the House of Commons on July 11 on a motion of Mr. A. Palmer's on the use of nuclear power stations constructed under the civil programme of the Central Electricity Generating Board for the production of military plutonium elicited a sharp reply from the Parliamentary Secretary to the Ministry of Power. Sir Ian Horobin repeated the specific assurance that all the capital costs of the civil stations will be met and it is the firm intention of the Government, the Atomic Energy Authority and the Central Electricity Authority, in fixing the prices at which the fuel rods will be bought back, to take account of any additional operating costs incurred in neutralizing them. Sir Ian said that a vital part of the economic calculations of the competitive position of nuclear power stations depends upon the number of megawatt-days per ton of uranium obtained from a uranium slug. It should not be taken that any of the slugs in any of the reactors, whether they required modification or not, will remain in the piles for a time different from that under the original programme. Information on high irradiation is required and we cannot wait for developments at Hinkley Point, which is not yet in operation; there is nothing to stop certain elements being left in the Generating Board's reactors to see if they can be burnt to the desired length. For the export trade we are simply concerned with the prices at which the slugs will be sold and bought back, and Sir Ian thought the overseas purchasers may well prefer to get rid of their slugs at a short rate of irradiation rather than otherwise. That price must be settled as part of the contract, and in conclusion Sir Ian, pointing out that the changes are marginal and that plutonium is produced initially in this type of reactor, emphasized that the costs on the defence side must be incurred anyhow, and expressed the hope that no suggestion would get abroad that we are making fundamental changes in these reactors and hinder the development of a promising and vital civil nuclear programme.

Developments in Nuclear Energy

In a written answer in the House of Commons on July 14, Sir Ian Horobin, for the Minister of Power, stated that the Safety Branch of the Atomic Energy Authority is being strengthened in accordance with the recommendations of the Fleck Committee, and the Government is preparing legislation to implement the policy of licensing and inspection which he had outlined on February 10. Also in a written answer, the Prime Minister said on July 15 that experimental work on thermonuclear fusion at the Atomic Weapons Research Establishment at Aldermaston is directed towards a better understanding of the mechanism by which high gas temperatures can be achieved. The encouraging results to date do not alter earlier predictions about the probable time-scale of the development of thermonuclear power. The Atomic Energy Authority is recruiting some additional staff for this work. Replying for the Prime Minister on July 17, Mr. R. A. Butler said that the agreement under negotiation with the Euratom Commission is likely to contain provisions similar to those in the agreement with the Italian Government, which provide for the supply of fuel by the United Kingdom and for assistance in the manufacture of fuel elements in Italy in due course. The role of the Euratom supply agency is a point to be taken into account in these negotiations and the Commission has given assurances that it does not intend to erect any obstacles to the development of nuclear power in its member countries. Pressed further on the point, Mr. Butler said he hoped that British technical contact with the Euratom Commission would be close.

Engineering Research

In an oral reply in the House of Commons on July 1, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, representing the Lord President of the Council, said that to get its research results across to members, particularly at the shop-floor level, the Production Engineering Research Association had developed an effective liaison and advisory service, on which one-third of its resources were spent. Short instructional courses on new production techniques were held in the Association's Melton Mowbray laboratories, which had been attended by about 1,650 persons during the past year, and a mobile unit had provided 150 practical demonstrations in members' works. About 3,000 technical inquiries were answered each year. He undertook to see whether the connexion between East Kilbride, engineering firms and universities in Scotland was sufficiently close. In reply to a further question, Mr. Nicholls said that for some years the Mechanical Engineering Research Laboratory had sponsored at universities, and itself conducted, research on heat transfer under various conditions of steam condensation and it had been demonstrated that condensation of steam on cooling surfaces as separate drops had great advantages in speed over normal film condensation. Chemicals had been developed which when applied to brass or copper surfaces produced this 'drop' condensation, and the method had been tried to some extent in industry. If it proved really successful the size of condensers would be halved.

Distribution of Industry

In introducing the Distribution of Industry (Industrial Finance) Bill, which was generally welcomed and received an unopposed second reading in the House of Lords on July 15, Lord Mancroft said that since the Distribution of Industry Act was passed in 1945 the pattern of unemployment in the country had changed. In some places in the development areas Government-financed factories were at present themselves providing work for nearly 200,000 people, apart from work provided by firms attracted to those areas without Government assistance; but in other places outside the development areas unemployment had become high and might remain high. The Government believed it was as important to assist those places as to assist the development areas, and accordingly the Bill proposed to extend the powers given to the Treasury under the present Act to make grants or loans to industry in the development areas to include places outside those areas where the Board of Trade was satisfied that the money would assist to reduce a high rate of unemployment which might otherwise be expected to continue. The Bill would also enable grants or loans to be made to undertakings engaged in trade or business as well as in industry, and Lord Mancroft explained that the Bill purposely did not define either the places or the undertakings which would be covered. This was to ensure the maximum flexibility, and Lord Mancroft said that banks, insurance companies, hire purchase companies, hotels and office organizations generally might be included. He undertook to look carefully into a technical point raised by Lord Conesford regarding the bearing of the Bill on the proper distribution of industry. Viscount Hall, in welcoming the Bill, quoted the Board of Trade estimate that expenditure on factory building of £70 million under the original Act over twelve years represented 90 per cent of expenditure under that Act and that loans had totalled £6,900,000.

Fuel Abstracts

Asked for a statement in the House of Commons on *Fuel Abstracts* on July 2, Mr. H. Nicholls, as representing the Lord President of the Council, said in a written answer that before deciding to discontinue *Fuel Abstracts* the Department of Scientific and Industrial Research consulted the Ministry of Power, the National Coal Board, the British Coal Utilization Research Association and other organizations. Careful examination showed that the various sections of *Fuel Abstracts* were covered wholly or in part by other abstracting organizations. Discussions have taken place with the National Coal Board as to ways and means of arranging for abstracting organizations in Britain to extend their present coverage and for the provision of some form of joint index. The Society of Chemical Industry is increasing the coverage of abstracts within its field of interest, while the Institute of Fuel is considering the possibility of issuing collected abstracts of fuel literature. The Department had had arrangements with abstracting organizations which do not make their abstracts directly available to the general public, whereby abstracts of fuel literature could be published in *Fuel Abstracts*, and there was no reason to suppose that similar arrangements could not be made by any other organization which publishes collected abstracts of fuel literature.

International Geophysical Year: Meeting in Moscow

The fifth meeting of the Special Committee (C.S.A.G.I.) of the International Geophysical Year is being held during July 29–August 9 in the Moscow State University. The meeting is reviewing the achievements of the International Geophysical Year since its commencement on July 1, 1957, and also the scheme now in operation for the deposition and exchange of results between the three data centres set up for each of the International Geophysical Year disciplines. During the course of the meeting there will be many discussions of a technical nature concerning preliminary results, and in addition there will be a symposium lasting several days concerning the rocket and artificial Earth satellite programme. A meeting of the Special Committee for Antarctic Research set up by the International Council of Scientific Unions is to consider research programmes in the Antarctic region after the closing of the International Geophysical Year programme on December 31, 1958.

Tax Concessions on Subscriptions to Learned Societies

When the tax concessions to individuals on their fees and subscriptions to learned societies and professional bodies, contained in the Finance Bill, were debated in the House of Commons on July 17, objections were raised to the limitation of the concession to bodies which were "not of a mainly local character". Mr. J. E. S. Simon, Financial Secretary to the Treasury, explained that the Inland Revenue had already to examine the claims of some 3,000 national societies and to extend it to all the local bodies would involve an administrative task in which the benefit to individuals would be out of all proportion to the expense involved. He fully appreciated the claims of many local societies but insisted that the relief to the individual tax-payer had to be balanced against the cost to the general body of tax-payers. He undertook, however, to put the views expressed before the Chancellor of the Exchequer. Mr. Simon also said that it was not a condition of relief that the employer should stipulate membership of a professional body; it was sufficient that the registration should be a condition for the performance of the claimant's duties. The views of the employer were no longer relevant. He also added that the clause would not be construed narrowly by the Inland Revenue, but in a common-sense way, with a desire to help professional men who could bring themselves fairly within its terms.

Journal of Nuclear Energy

It has been announced that the *Journal of Nuclear Energy* is shortly to be issued in two parts (*A* and *B*) dealing respectively with basic reactor science and reactor technology. Part *A* will continue to be published monthly with little alteration and will consist of papers dealing with the scientific, biological and economic aspects of nuclear energy. Part *B* will be published quarterly and the first issue will appear in time for the Second Geneva Conference. It will be devoted to technological subjects contributing to the development of nuclear energy for peaceful purposes and will contain papers on mathematics (including computing for design purposes); applied physics; fuel processing and plant criticality; heat transfer; fuel element design and fabrication; and other scientific aspects of the construction and operation of nuclear reactors. The editors direct attention to three important characteristics of Part *B*: the international character of the journal; the high scientific and professional standard; and the short publication time. Both parts of the journal will contain translations of relevant papers published in the Russian journal of atomic energy, *Atomnaya Energiya*.

Progress in Rubber Technology

The current annual report on the "Progress of Rubber Technology" (edited by Dr. T. J. Drakeley, Pp. xi+134. Cambridge: W. Heffer and Sons, Ltd., 1958. 25*s*.), issued by the Institution of the Rubber Industry, gives a brief but reasonably detailed review of developments up to the end of 1957. All aspects of the industry, scientific, technical and economic, are included, and the arrangement in the form of short chapters on specific topics makes for easy reading and quick reference. The subject-matter is not limited to rubbers, but includes materials, such as fibres and plastics, which are used either in association with rubbers or as alternatives to them. Every branch of the industry, including tyres, belting, cables, footwear, cellular rubber, flooring and roads, is covered, and other chapters deal with subjects of more general scientific interest, though these form only a small proportion of the whole. The main value of this publication is that it enables the reader to keep in touch with developments outside his own speciality, and to obtain a quick appreciation of general trends in the industry. Foremost among these is that—in spite of the continued advance of synthetic rubbers and of materials designed to satisfy particular technical requirements—the total demand is expanding at such a rate that the market for natural rubber has remained remarkably stable, and new planting is in progress in various parts of the world. There appears also to be a lively development of scientific interest in new ways of using natural rubber, particularly in conjunction with other polymers, to meet the threat of competition from the synthetics.

New Floristic Studies

The physiography of the vast and interesting region comprising the Canadian Arctic Archipelago has recently been described in a publication issued by the National Museum of Canada, "Illustrated Flora of the Canadian Arctic Archipelago", by A. E. Porsild (National Museum of Canada, Bulletin No. 146: Biological Series No. 50. Pp. iii+209. Ottawa: Queen's Printer, 1957. 2 dollars). The Bulletin also deals with the soils and plant habitats of the region; and numerous illustrations, species distribution maps and keys are provided. In all, some 340 species and major geographical races of flowering plants and pteridophytes are described. The author records that, in this and other floristic studies of the region which he has undertaken, the Canadian Arctic is defined as including all the land area—some 900,000 sq. miles—which lies north of the treeline, the latter, broadly speaking, following the 10° C. isotherm for the warmest month.

A rather different work, issued by the United States National Museum, Smithsonian Institution, Washington, D.C., as U.S. National Herbarium, 33; 1957, is "The Bromeliaceae of Colombia", by L. B. Smith (pp. vi+311. Washington, D.C.: Government Printing Office, 1957). This family is, of course, very abundantly represented throughout the American tropical and sub-tropical regions. Thus the author of the present monograph notes that, during the past twenty years, the record of known Colombian species has been practically doubled, some 372 species being now known. The Colombian Bromeliaceae fall into three groups: on the criteria of floral morphology, the Andean group is primitive, and the Guiana Highland and Amazonian groups are derivative. The rich representation of two species, *Tillandsia* and *Puya*, have led the author to the tentative conclusion that the family may have originated in Colombia.

Perkin Centenary Trust Awards

THE Perkin Centenary Fellowship has been awarded to Mr. Dennis Balmforth, of Messrs. Courtaulds, Ltd., Coventry, and will be tenable from October 1 in the Department of Colour Chemistry at the University of Leeds. Perkin Centenary Scholarships have been awarded to Mr. Brian Higginbottom, assistant chemist in the laboratories of the Bleachers' Association, Ltd., tenable at the College of Technology, Loughborough, and to Mr. W. K. McCourt, laboratory foreman with Messrs. Courtaulds, Ltd., Carrickfergus, tenable at The Queen's University, Belfast. Arrangements have also been made for a Perkin Exchange Lectureship whereby short visits will be exchanged between Prof. A. J. Birch, of the University of Manchester, and Prof. V. Prelog, of the Eidgenössische Technische Hochschule, Zurich. Prof. Birch will visit Zurich in September 1958, and it is hoped that Prof. Prelog will return the visit in the following year. Each will deliver one or more lectures during the visit, which will last about two or three weeks.

The programme of awards for the year 1959–60 will include one Perkin Centenary Fellowship, valued at not less than £600 a year, which is available to a graduate for higher study, and two Perkin Centenary Scholarships, of £300 a year each, which are intended to give young persons employed in the industries concerned with the manufacture or the application of colouring matters the opportunity of full-time education at a university or technical college. Further nominations are not at present invited for the Perkin Exchange Lectureship. In the place of this award the Trustees will consider making one or more Perkin Centenary Trust Travel Grants to enable teachers concerned in the study of any aspect of the manufacture or application of colouring matters at a university or technical college to make short visits to comparable institutions overseas in order to widen their experience. The Perkin Centenary Trust was established as a memorial to the discovery in 1856 of the first important synthetic dyestuff, mauveine, by William Henry Perkin. The secretary to the Trustees is Dr. J. R. Ruck Keene, to whom inquiries relating to the awards should be addressed, at the Chemical Society, Burlington House, London, W.1.

Announcements

SIR JOHN STOPFORD, lately vice-chancellor of the University of Manchester and emeritus professor of experimental neurology, has been created a baron under the provisions of the Life Peerages Act.

PROF. O. T. JONES, emeritus professor of geology in the University of Cambridge, has been awarded the Liverpool Geological Society Medal in recognition of his varied contribution to and lasting influence on the science of geology over the past half century, and particularly of his illuminating work on the Silurian of North Wales.

THE Council of the British Institution of Radio Engineers has announced the award of a number of premiums for original publications and prizes for outstanding performances in the Institution's graduateship examinations in 1957. The Clerk Maxwell Premium—the premier award for the most outstanding paper published in the Institution's *Journal* during 1957—is to go to Dr. T. B. Tomlinson for his paper, "Principles of the Light Amplifier and Allied Devices", based on work carried out at the research laboratories of the General Electric Company; he is now with Computer Developments, Ltd.

THE work in progress at the National Chemical Laboratory may be seen during the open days to be held on October 21 and 22. Applications from firms for invitations to the sessions should be sent to the director not later than September 20. Firms already on the mailing list for invitations need not re-apply. Further information can be obtained from the National Chemical Laboratory, Teddington, Middlesex.

THE fourth International Conference on Electron Microscopy, organized by the Deutsche Gesellschaft für Elektronenmikroskopie, will be held in Berlin during September 10–17. Further information can be obtained from Prof. E. Ruska, Berlin-Dahlem, Faradayweg 4–6.

THE Indian Central Fuel Research Institute is organizing a symposium on "The Nature of Coal" during February 9–11. Papers, not exceeding 3,000 words in length, with their abstracts, should reach the Director, Central Fuel Research Institute, P.O. Fuel Research Institute, Dhanbad Dist., Bihar, India, not later than October 31.

An informal discussion on "Isotopic Exchange Reactions", sponsored by the Faraday Society, will be held in the School of Chemistry, University of Leeds, on September 25 and 26. The programme will include applications of radioactive and stable isotopes to the study of liquid, gaseous and solid-gaseous systems. Further information can be obtained from Dr. D. R. Stranks, School of Chemistry, The University, Leeds, 2.

A COURSE on the control and instrumentation of reactors is to be held at the Harwell Reactor School during October 6–11. The fee for the course will be 25 guineas exclusive of accommodation. Further information can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell.

ERRATUM. In *Nature* of July 19, p. 158, under "University News: Bristol", for "Dr. J. W. F. McOmie" read "Dr. J. F. W. McOmie".

MECHANICAL PROPERTIES OF WHISKERS AND THIN FILMS

ON March 17–19 some sixty scientists met at the Cavendish Laboratory, Cambridge, and Tube Investments Research Laboratories, Hinxton Hall, for an informal discussion of nineteen papers on "The Mechanical Properties of Whiskers and Thin Films", invited from universities and industrial research laboratories in Great Britain and the United States. The main purpose of the meeting was to review the present state of knowledge on the high mechanical strength observed when one or two dimensions of a test specimen are reduced to a small value. The organizing committee consisted of Dr. F. P. Bowden, Mr. J. E. Gordon and Dr. J. W. Menter.

D. Turnbull (General Electric Co.) opened the proceedings with a survey of mechanisms of whisker growth. Whiskers can be grown either by spontaneous extrusion or by growth into physically or chemically supersaturated media. The former are very strong in bend tests (Galt and Herring) but not in tension tests. Plausible dislocation mechanisms for the observed growth from the root have been advanced by Eshelby, Frank and Seitz.

By contrast, whiskers appearing in physically supersaturated media grow at the tip although they appear to be nucleated at singularities on the substrate. A typical example is mercury, which, after an initial period of growth to a considerable length at a constant thickness of about 100 A., begins to thicken abruptly. Sears suggested that growth occurs by the action of a single axial screw dislocation, and this is supported by the field emission studies of Gomer. Whiskers grown in this way are strong both in bend and tension tests.

Similar mechanical properties are observed in whiskers grown from chemically supersaturated media, which have been extensively studied by Brenner. The growth mechanism is not clearly understood, but Frank has suggested that in some cases it may be controlled by the rate of chemical reduction at the tip or root.

Metal Whiskers

A number of papers then followed on the mechanical properties of metal whiskers. S. S. Brenner (General Electric Co.), in a paper on the plastic deformation of metal whiskers, first summarized the observations of himself and others on the elastic behaviour of whiskers. Elastic strains from 1 to 5 per cent have been reported with a maximum tensile strength of 1,400 kgm./mm.^{2} in an iron whisker about 2μ in diameter (but see Bacon below). Brenner has found that the plastic deformation of copper, silver and iron whiskers occurs by the motion of a Lüders band at a stress sometimes as small as 1 per cent of the yield stress. The local plastic strain in the Lüders band remains constant at values ranging from 0·25 to 0·40 during propagation, depending on the diameter of the whisker. Cross-slip can readily occur at these strains, suggesting that slip may extend along the whisker by a double cross-slip mechanism. Lüders bands are more difficult to observe in iron since extensive local deformation occurs within the band. This local slip is very sensitive to the applied stress, with the result that at high stresses fracture occurs before much of the whisker has slipped. No appreciable part of the elastic strength of whiskers can be recovered by annealing at temperatures up to 600° C. Creep has been observed in iron whiskers and a linear region can usually be observed in which the creep-rate varies roughly exponentially with the applied stress.

N. Cabrera described experiments on the creep of vapour-grown zinc and cadmium whiskers carried out at the University of Virginia with H. H. Hobbs and P. B. Price. An initial non-linear region is observed in the stress – strain curve followed by yield at strains of the order of 1 per cent. If the stress is maintained constant below yield for several hours, creep is observed, the initial creep-rate increasing with the applied stress. A saturation value is finally reached, and once creep has been exhausted at a particular level no more creep is observed at any other level. These results are tentatively interpreted as due to pinned-down dislocations (of the order of 10^8–10^9 cm.$^{-2}$) already present, most of which are pushed out of the whiskers during the creep process, leaving a much more perfect crystal, which then yields at higher stresses (1·5–2 per cent strain). The pinning may be associated with impurities which may be present in concentrations of the order of 10^{-4} impurity atoms per pure atom if the residual resistance observed at liquid-helium temperature is interpreted as due to impurities.

From optical and electron microscope replica studies of copper whiskers, G. A. Geach and P. E. Charsley (Associated Electrical Industries Research Laboratories, Aldermaston) deduced that slip in the Lüders band occurs on only one system, with the implication that the band is not propagated by a double cross-slip mechanism. In whiskers with a $< 211 >$ axis it appears that the slip system in the Lüders band is not that corresponding to the maximum resolved shear stress. The slip distance is observed to depend on size. 5-μ whiskers showed slip steps with up to 0·7μ glide, whereas the amount of glide was only a few hundred angstroms or less for the slip steps on a 20-μ whisker.

The surface characteristics of copper whiskers have been studied by D. Vermilyea (General Electric Co.). D. Turnbull, in presenting this work, suggested that both the physical and chemical behaviour of whiskers free from dislocations except for an axial screw might be unique if their side-walls are perfectly smooth and densely packed. Vermilyea has studied the overpotential required to discharge cupric ions or dissolve copper metal at the surface of copper whiskers. On bulk copper these processes occur at relatively small overpotentials (about 5 mV.) and apparently uniformly over the entire surface. However, overpotentials of about 100 mV. and 20 mV., respectively, are required to discharge cupric ions or dissolve copper metal at the surface of a 3-μ copper whisker, and the electrolytic action occurs only at a few small areas not including the whisker tip. These observations suggest that the surface of these whiskers may indeed be very smooth and with certain reservations may be taken to imply that the density of dislocations in the whisker may be very low.

G. A. Bassett (Tube Investments Research Laboratories, Hinxton) briefly described a new technique for revealing surface steps down to atomic dimensions, which might be useful for studying the surface perfection of whiskers. Evaporated gold layers are found to be nucleated preferentially along step edges on some ionic crystals. These nuclei are detached by means of a carbon film and used as a 'decoration replica' for observations on surface-step structures. It is not known whether similar effects could be obtained on metallic surfaces.

Some qualitative evidence on the dislocation structure in iron whiskers 10–200μ in diameter with axes in < 100 >, < 110 > and < 111 > directions was presented by R. V. Coleman (General Motors Corp.). Well-defined etch pits connected with dislocations are observed on {100} faces using 4 per cent picral or 2 per cent nital etchants. Perfectly oriented {100} surfaces do not in general develop etch pits, although random groups of pits are observed on some other surfaces. These are of two types: a 'sharp-bottomed' pit which develops rapidly, and a rounded flattened pit which develops more slowly. Larger numbers of the former develop after plastically deforming the whiskers, the density increasing with deformation and remaining constant with time for a given deformation. After annealing at 850° C. for some hours and etching, polygonized and other arrays of dislocations can be seen.

Non-metallic Whiskers

C. C. Evans, D. M. Marsh and J. E. Gordon (Tube Investments Research Laboratories, Hinxton) described observations on the properties of non-metallic whiskers of hydroquinone, nickel sulphate, sodium chloride, potassium chloride and potassium permanganate. Optical studies show that growth occurs from an initial very thin 'leader' crystal in the micron range, which then thickens by the longitudinal spreading of growth layers. A needle habit can be induced in sodium chloride by the addition of very small quantities of polyvinyl alcohol or sucrose to a saturated aqueous solution. Mechanical tensile tests on crystals of sodium chloride between 1 and 200μ^2 grown in this way have been made with a special testing machine developed by Marsh. Below 2μ^2 the whiskers are fully elastic up to fracture at a strain of about 1 per cent, but with increasing size the elastic limit falls and an increasing region of plastic deformation is observed. In the ductile region, slip bands and local necking are observed, and the largest specimens show some work hardening. The machine is not at present suitable for detecting a sharp yield point.

P. E. Charsley (Associated Electrical Industries Research Laboratories, Aldermaston) has investigated the structure of whiskers of sodium and potassium chlorides by electron microscopy and diffraction. Sodium chloride shows a predominant < 100 > orientation with occasional < 110 >, whereas potassium chloride whiskers are invariably < 110 >. The most common shape of sodium chloride whisker is bounded by two parallel {100} planes, the other surfaces being irregular, since the edges of growth layers appear to originate in the centre of the {100} faces. These whiskers frequently disintegrate during direct examination under the electron microscope, the larger ones revealing a substructure bounded by < 100 > directions and the smaller (a few tenths of a micron in diameter) showing no regular substructure. This dependence of the substructure on size is correlated with evidence for a layer structure obtained from carbon-replica studies, and it is suggested that layer growth results in lattice imperfections which may be the cause of the decrease in tensile strength with increasing diameter observed by Gyulai.

A. Berghezan (European Research Associates) presented a paper by R. Bacon (National Carbon Research Laboratory, Union Carbide Corp., U.S.A.) describing some interesting observations on graphite whiskers grown by a high-pressure arc process. Whiskers 0·5–5μ in diameter and several millimetres in length show a remarkably high fracture strength of 2,000 kgm./mm.^{2} at an elastic strain of 2 per cent. Most of these whiskers exhibit a ribbon-like form which are often single crystal over their entire length, with the *c*-axis perpendicular to the axis of the whisker. Some whiskers are cylindrical, but again X-ray examination shows that the *c*-axis is normal to the axis of the whisker in all azimuths, suggesting a structure consisting of one or more concentric tubes each of which is essentially a large sheet, many atomic layers thick, rolled up into a tight spiral scroll. Growth is thought to occur by addition of carbon to the spiral edge of the rolled-up sheet so that the whisker elongates rapidly (10 in./hr.). The elastic modulus of these whiskers is about 100 times that of bulk polycrystalline graphite.

Some aspects of the theory of dislocations in whiskers were considered by J. D. Eshelby (Department of Metallurgy, Birmingham) and J. P. Hirth (Carnegie Institute of Technology). The former described a method for calculating the twist which an axial screw dislocation produces in a whisker of arbitrary cross-section, and briefly discussed the stability of the dislocation. Hirth considered the possibility of thermally activated slip of dislocations out of metal whiskers, as a possible mechanism for the cessation of whisker growth. Whiskers with radii less than a critical value will not retain a single axial dislocation. Above the critical radius the dislocation will slip out only if it has an edge component of about 0·3 times the Burgers vector with respect to the axis of the whisker. The effects on whisker morphology predicted by this mechanism were shown to be consistent with observation.

Most of the evidence on crystalline whiskers seemed to indicate a fairly definite dependence on size of mechanical properties. Earlier work on non-crystalline glass fibres followed the same trend, but more recently it has been shown that if care is taken to avoid surface damage, strength is virtually independent of fibre size. The problem of size, strength and structure in glass was discussed in a paper by M. E. M. L. Parratt, D. M. Marsh and J. E. Gordon (Tube Investments Research Laboratories, Hinxton). On the assumption that failure is associated with surface defects, an improved sodium decorating technique has been used to study surface crack patterns and definite correlations have been made between their extent and the mechanical strength. These crack patterns present on the surface of all fire-polished glass seem to control the mechanical strength up to at least 3 per cent strain. The origin of these cracks is not clear. Electron microscope studies on thin films of glass showed that devitrification could lead to cracks, but an alternative source was abrasion, the susceptibility to which may be associated with the state of stress of the surface.

The importance of the surface condition was emphasized by D. G. Holloway (University College of

North Staffordshire), who has found that the bending strength of 60–120-μ 'Pyrex' fibres is larger by a factor of 5–6 when drawn and tested under high vacuum compared with those drawn and tested in air or those drawn in vacuum and tested in air. The drop in strength was attributed to atmospheric attack on the surface.

Thin Films

D. W. Pashley (Tube Investments Research Laboratories, Hinxton) has studied the tensile deformation of single-crystal films of gold in (111) orientation, 500–2000 A. in thickness, inside the electron microscope. No movement of the grown-in dislocations (10^{10}–10^{11} cm.$^{-2}$) was observed as the strain was increased to about 1 per cent, and this strain was confirmed as elastic by measurements on electron diffraction patterns from the strained film and by means of stress-strain measurements carried out externally by D. Marsh.

At an elastic strain of about 1 per cent the film was observed to fracture by the propagation of a highly localized region of plastic deformation along the film corresponding to slip on $(11\bar{1})$, $(1\bar{1}1)$ and $(\bar{1}11)$ planes. This led to complete fracture of the thinner films, but with thicker films short regions where fracture occurred were joined by regions of less localized plastic deformation.

T. Evans (Tube Investments Research Laboratories, Hinxton) described experiments in which similar single-crystal films of gold, gold/palladium, rhodium and platinum oriented on substrates consisting of single crystals of silver were deformed as a result of tensile stress applied to the substrate. In this situation the film may become deformed plastically with the substrate up to large deformations, provided dislocations from the substrate are able to pass into and through the film. The important determining parameters are the relative lattice misfit between film and substrate and the relative elastic moduli. Examination by transmission electron microscopy of films stripped after deformation showed that gold and gold/palladium accommodated the strain of the substrate by slip, whereas platinum and particularly rhodium films had many cracks following the traces of slip planes in the substrate, implying that the film had cracked locally due to the stress concentration arising from piled-up groups of dislocations on the substrate slip planes immediately below the film.

P. B. Hirsch and M. J. Whelan (Cavendish Laboratory, Cambridge) considered the factors determining the strength of thin metal foils with free surfaces, inferred from their direct observations in the electron microscope. Moving dislocations leave behind traces at the top and bottom surfaces, which are thought to be surface dislocations held up at the interface between the metal and an oxide or other type of surface film.

For a thick oxide film the stresses required to move dislocations approach the critical Frank–Read stress of the dislocation line in the metal film. Estimates of this stress from curvature of the line suggest that some dislocations move under stresses of about $G/1{,}000$ in foils about 1000 A. thick. Although in favourable circumstances it is expected that a Frank–Read source might operate, no direct observation of such a source has been made.

However, dislocations have been observed to nucleate near the edge of a thin foil. The dislocations appear to be half loops which have run in from the edge. Following a suggestion by Cottrell, nucleation of dislocations in a wedge crystal has been considered theoretically. It is found that, for a dislocation with Burgers vector in the surface of a thin foil with a wedge angle of 0·1 radian, the activation energy for nucleation is about 1 eV. at stresses of the order of $G/150$. This theory may possibly account for the observed nucleation in the majority of cases.

B. A. Bilby (Department of Metallurgy, Sheffield) also considered theoretically the nucleation of slip in thin plates, using solutions of elastic equations given by Leibfried and Dietze and by Eshelby and Stroh. For a long straight screw dislocation parallel to the plane of the plate a significant reduction in the activation energy occurs only at very high stresses or for very thin plates. A calculation was also made for the introduction of a pair of screw-dislocations lying normal to the plate, with results confirming in order of magnitude those of Hirsch and Whelan for the thin wedge. The energy of steps forming and disappearing on the surfaces as the dislocations are introduced plays an important part, but more detailed models are required to assess their effect quantitatively.

J. Nutting and D. G. Brandon (Department of Metallurgy, Cambridge) have tested iron foils, 99·97 per cent pure, in tensile deformation, with different thickness and grain size. The yield stress and extent of yield decreased and the rate of work hardening increased with decreasing foil thickness (down to less than 30μ). In coarse-grained foils the yield phenomenon was less affected than in the fine-grained. Factors affecting the behaviour of the foils include stress concentration due to local variation in thickness, decrease of constraints on individual grains, triaxial stress distributions resulting from surface rumpling during deformation and possible changes in the dislocation mechanism for deformation. No evidence for the last had been found by transmission electron microscope studies on thinned foils, although more deformation and kink bands and relatively few slip lines are seen on the surface of the thinner foils.

R. B. Nicholson (Department of Metallurgy, Cambridge) showed that the coherency strains associated with Guinier–Preston zones in aluminium/4 per cent copper alloys could be made directly visible in thin films of the alloy studied in the electron microscope and discussed their effect on the age-hardening characteristics of this alloy. G. Thomas (Department of Metallurgy, Cambridge) has studied precipitation phenomena and dislocation structures in thin foils of aluminium/magnesium/zinc alloys in the electron microscope. When previously aged beyond maximum hardness it is possible to cause movement of dislocations in the foils by heating in the electron beam. The chief sources of dislocations appear to be the grain boundaries. The stresses obtained by heating appear to be insufficient to move dislocations through precipitates.

As was intended, the papers given were essentially accounts of work in progress, and it is therefore not easy to give a considered view of the field as a whole. Explanations of the high strength of whiskers start from two conflicting assumptions about their microstructure. Some whiskers are undoubtedly highly perfect and it is reasonable to expect these to show a long elastic range. Whether surface perfection is essential for strength in addition to interior perfection depends on the view taken of the possibility of nucleation of dislocations or cracks from surface irregularities. The alternative view is that whiskers may well be imperfect, but high strength may still be observed because of the pinning of dislocations and inhibition of sources due to the small dimensions of the specimen. Both the latter strengthening mechanisms have been shown to be plausible for thin films from direct observation in the electron microscope, and it would be valuable to have more direct information of a similar nature about whiskers. Equally it would be valuable to have much more information about the relation between strength and thickness for thin films.

It is important to know more about changes in mechanisms and modes of deformation with thickness and also whether a small thickness alone is adequate to achieve high strength. The structure of the film arising from the particular method of preparation may also turn out to be important.

J. E. GORDON
J. W. MENTER

CHEMISTRY OF PLANT PRODUCTS

THE Royal Australian Chemical Institute's Western Australian Branch, in co-operation with the University of Western Australia, held a symposium on "Plant Products" at the Chemistry Department of the University on March 20 and 21. The first day was devoted to general and technological papers and the second mainly to structural chemical investigations. About 45 members and guests attended the two sessions.

After introductory remarks by Dr. D. E. White, president of the Branch, who welcomed the visitors, Dr. J. R. Price (Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne) outlined the development of phytochemistry in Australia, from the pioneers, like the Surgeon of the First Fleet, to its present flourishing state. Work in this field is carried on in most of the Universities and also by the Commonwealth Scientific and Industrial Research Organization. After discussing briefly the role of these institutions, Dr. Price summarized the scope, organization, objectives and potentialities of current work in the Division of Industrial Chemistry. Mr. R. H. Pearce (Kwinana Chemical Co., Kalamunda) described the application of solvent extraction and chromatography to the separation of fractions from *Xanthorrhoea* resins. Variations with species and age of the resin were discussed and some components were found to be unstable in light and air. The techniques used appear much more promising than those previously used in attempts to isolate compounds from this resin.

An account of the use of growth regulators in viticulture was given by Mr. L. T. Jones (Department of Agriculture, Perth), who described the effect of hormone spraying in place of the obsolete and harmful practice of cincturing vines. Local research work illustrated the superiority of such hormones as PCPA, 2,4-dichloro- and 2,4,5-trichloro-phenoxyacetic acids and gibberellic acid, resulting in increased production, improved fruiting, prevention of preharvest fruit drop and the killing of unwanted vines. Reference was made to the disadvantages of hormone spraying, for example, damage to bunches and vines, but these were due to incorrect application of the spray. Mr. Jones pointed out that gibberellic acid (not strictly a hormone), had been used experimentally only recently, and the results obtained suggest a promising future for the use of this material in viticulture. A striking contrast between the sizes of bunches on treated and untreated vines was shown in colour slides.

Mr. W. E. Hillis (Division of Forest Products, Commonwealth Scientific and Industrial Research Organization, Melbourne) discussed chemical aspects of the sapwood-heartwood transformation, referring particularly to the increased polyphenolic content of the heartwoods of Australian timber trees. These components, which contribute to durability, may be derived from the cambium, the leaves or the starch in the sapwood, and evidence indicates that an appreciable portion arises from the latter. The significance of the shikimic acid content of *Eucalyptus sieberiana* leaves of different sizes, before and after shading, was discussed.

Dr. H. Jakobs (Leederville, W.A.) described how chemical research had made possible much of the agricultural development in the Dutch East Indies. He exemplified this in detail by reference to the tea industry, which is now of major importance in Indonesia.

Dr. D. E. White discussed a study made with D. K. Dougall on the 'primary' tars, obtained by distillation of jarrah and karri sawdust *in vacuo*. Among the compounds isolated catechol, 2 : 6-dimethoxyphenol, 1 : 2 : 3-trihydroxybenzene, 5-methylfurfural and D-glucosan (1 : 5)β(1 : 6) were identified. Decomposition of the latter was responsible for the low decomposition temperature of the tar.

The second day's proceedings opened with a paper on the chemistry of stock poison-plants by Dr. C. C. J. Culvenor (Division of Industrial Chemistry, Commonwealth Scientific and Industrial Research Organization, Melbourne) read by Dr. J. R. Price. The liver-damaging pyrollizidine alkaloids and their N-oxides isolated from Compositae, Leguminosae and Boraginaceae were described with special reference to the recognition of monocrotaline from *Crotalaria retusa* as the cause of Kimberley horse disease. Recent work on other *Crotalaria* spp. was also discussed.

Dr. P. R. Jefferies (Chemistry Department, University of Western Australia) outlined the principles of gas chromatography and showed how it could be used for the quantitative analysis of simple mixtures. Complex mixtures as found in essential oils can be studied qualitatively, first on the whole oil, and then on distillation fractions. In this way the isolation of pure compounds is greatly facilitated and the presence of high-boiling components can be easily detected.

The constitution of the sesquiterpene alcohol globulol was discussed by Mr. G. J. H. Melrose in a joint paper with P. R. Jefferies and D. E. White. He described new sources of this alcohol in Western Australian Myrtaceae, and the synthesis of an epimer by the reaction of methyl magnesium iodide with apoaromadendrone. This alcohol also affords aromadendrene on pyrolysis of its 3 : 5-dinitrobenzoate. Hence the junction of the 5 and 7 membered rings in aromadendrene must be the more stable (*cis*) type. Other features of the stereochemistry of globulol and *epi*-globulol were also discussed and evidence for the attachment of the *cyclo*propane ring to C_6 and C_7 was outlined.

The chemistry of *Lunasia* alkaloids was discussed by Dr. J. R. Price, who compared the American work on *L. amara* with that done in the Commonwealth Scientific and Industrial Research Organization on *L. quercifolia*. In addition to the tertiary bases, lunacrine and lunacridine, water-soluble bases were present, the major component of which analysed for $C_{17}H_{22}O_3N^+$. A possible structure for this compound, which forms lunacridine when treated with alkali, was presented.

Mr. J. O. Knight presented the final paper in collaboration with A. R. H. Cole, D. C. Shaw and D. E. White, on triterpenoid constitutents of the Myrtaceae. After discussing the common occurrence of betulic acid in members of this family he dealt with the structure of melaleucic acid. The structure originally assigned (3β-hydroxylup-20(29)–en–25 : 28-dioic acid; *Chem. and Indust.*, 926; 1956) cannot be correct since the lactone which was assumed to involve the 3-hydroxyl and the 25-carboxyl affords a tertiary hydroxyl group on reduction with lithium aluminium hydride. The second carboxyl group must be on C_{26} or C_{27} and its lactonization involves re-arrangement. Means for distinguishing between these possibilities were discussed.

D. E. WHITE

THE INSTITUTE OF BIOLOGY

ANNUAL CONVERSAZIONE

THE annual conversazione of the London Branch of the Institute of Biology was held at University College on the evening of July 3. Prof. G. P. Wells and Dr. K. Mellanby (chairman of the London Branch) received members and their guests in the North Cloisters of the College. A large number of exhibits was on display in the Zoology Department, by courtesy of Prof. Wells.

The range of activities of this year's guest Society, the Botanical Society of the British Isles, was well shown by its exhibit. Of particular interest was its progress in the scheme to produce a map of the distribution of British plants. The mass of data for this scheme has been reduced to a minimum of space by the use of a punched-card system, and it is hoped that an atlas of British plants will be produced in 1960. A related project has been undertaken by the British Naturalists' Association, whose exhibit illustrated their work on a phenological survey which will map the changes in the flora and fauna which occur during the year and also the fluctuations of longer period.

Hospital and Laboratory Supplies, Ltd., provided this year's trade-stand, which gave a sample of the comprehensive range of apparatus and materials which this firm can supply. Specimen publications of the Universities Federation for Animal Welfare and of the Institute of Biology were on display, and the Department of Extra-Mural Studies of the University of London had produced an exhibit to illustrate the work of the Department in the field of biology.

Aspects of the Falklands Islands Dependencies Survey biological research were shown, including the method of ageing individual seals by the annual increments of dentine or cementum in the teeth, and also illustrating work on the reproductive cycle of the southern elephant seal. The Ministry of Agriculture, Fisheries and Food provided a stand showing advances in food research and development, particularly in food dehydration, and its Infestation Control Division was represented by Mr. G. A. Brett's exhibit of a common tropical cockroach, *Pycnoscelus surinamensis*, which is occasionally imported into Britain.

In addition to the exhibits of organizations, a large number of exhibits had been provided by members and guests. Studies on pest control provided the basis of several of these. An example of a serious infestation of a house by the ant *Lasius brunneus* was found in 1957 (A. A. Green), and there is some evidence of an increased tendency for this ant to invade houses. Population studies of locusts (R. F. Chapman) have made it necessary to be able to separate the egg-pods of locusts from those of other species; various characteristics of the pod can be used. The way in which infestation in a bulk of grain causes heating (D. H. Burges) introduced a model showing the rate of development of colonies of the flat grain beetle (L. P. Lefkovitch), colonies of up to 550,000 individuals being produced in 4 months.

A more gradual example of population increase was shown by the frog *Rana ridibunda* (J. I. Menzies); 12 specimens were introduced into England in 1935, and their descendents have spread at the expense of the British *Rana temporaria* and now cover 120 square miles of S.E. England. New anatomical work on the classification of the lugworm genus *Arenicola*, which can be divided into two groups, was shown by Prof. G. P. Wells, with a map of the zoogeography of this genus. Two very different types of colour change in the Orthoptera were shown (K. H. L. Key), some acridids showing a physiological change from black to blue as a direct reaction to increasing temperature, while some phasmatids show centromorphic colour changes related to population density.

Some exhibits were concerned with genetical studies. Studies on finger-print patterns (S. B. Holt) have shown that the total ridge-count is determined by additive genes with an independent effect but without dominance. In the fungus *Aspergillus nidulans* (M. Mahoney and D. Wilkie) some spores give rise only to asexual colonies; this appears to be due to the loss of a self-replicating cytoplasmic unit. The rare genetically determined biochemical defect in man known as gargoylism (U. Mittwoch) can be detected by the presence of abnormal inclusions in the lymphocytes.

An exhibit of the different degrees of specificity of both the bacteria and the leguminous plant in their symbiotic relationship (P. S. Nutman) showed also the way in which different mutant strains make it possible to study how the relationship develops. New methods of studying the cellular constituents of yeast (A. A. Eddy) have resulted from the discovery that protoplasts can be prepared by treating yeast cells with certain digestive enzymes of the snail *Helix*.

Exhibits concerned with research techniques included the compact lightweight McArthur microscope, designed for field-work; new uses for cellulose acetate in the culture of anaerobic bacteria and in electrophoresis (W. H. Pierce); and the confining of insects to treated plants under controlled conditions, for use in insecticide screening (D. T. Saggers).

There were many other exhibits, of no less interest and attractiveness than those mentioned above, and the exhibits as a whole provided starting-points for the informal discussion and conversation between those present which are, after all, the prime purpose of a conversazione.

C. B. Cox

MARIAN SMOLUCHOWSKI

MARIAN SMOLUCHOWSKI, the great Polish theoretical physicist, died during the First World War on September 5, 1917, in Cracow, and a description of his life and work was published by A. Teske three years ago ("Marian Smoluchowski: His Life and Work". Polish State Scientific Publishing House, Cracow, 1955). However, for those not familiar with the Polish language, the brief account of Smoluchowski's career and of his contributions to the theory of probabilities in physics given in the article contributed by S. Ulam to the October number of *The American Journal of Physics* (25, 475; 1957) will be very welcome.

Smoluchowski was born in Vienna in 1872. His father was a Cracow lawyer who later became secretary of the Chancellery at the Court of the Emperor Francis Joseph. His mother, too, was well educated, and Smoluchowski was brought up in highly intellectual surroundings. He early showed an interest in science and he studied mathematics and physics at the University of Vienna, attending the lectures given by Boltzmann, Mach and others. He published his first scientific paper in his second year at the University, finally graduating with the highest honours. After a year in Paris working with Lipmann, he studied for a year in Glasgow under Kelvin and then spent a few months in the laboratory of Prof. Warburg in Charlottenberg, finally returning to Vienna to become a lecturer in the University of that city. In 1899 he became a lecturer in Lwow, and the next year, at twenty-eight, he was promoted to a chair of theoretical physics, thus becoming the youngest professor in Austria. In 1913 he was offered, and accepted, the chair of experimental physics at Cracow, but was evacuated to Vienna in the early part of the First World War. The University of Cracow made him rector when he was invited again in 1917 to the chair of theoretical physics in Vienna, but Smoluchowski died suddenly at the age of forty-five before he could deliver his inaugural address entitled "On the Uniformity of Laws of Nature".

Probability theory played an important part in physics during the forty years following Smoluchowski's premature death, and Smoluchowski can claim to have started and anticipated much of the subsequent development. He, together with and independently of Einstein, elaborated and carried forward the ideas of Maxwell and Boltzmann. One of Smoluchowski's mathematical achievements was the clarification of the ergodic hypothesis of Boltzmann and of its place and meaning in statistical mechanics. He realized the difference between the logical structure of the Maxwell and Boltzmann theories and the statistical mechanics of Gibbs. Though primarily a theoretical physicist, Smoluchowski was also very adept in the design and construction of instruments and an extremely good glass-blower. While at Lwow he carried out a brilliant series of experiments confirming Lord Rayleigh's theory that the blue of the sky was caused by the scattering of light. He paid several visits to Great Britain both for mountaineering in Scotland (one of his great passions), and also on academic business. He was an active member of many scientific societies, in particular the Polish Physical Society, of which he became the first president, and he contributed many papers to scientific periodicals, some collections of which have been published since his death.

MENTAL HEALTH RESEARCH FUND

OFFICIAL figures show that in 1956 there were in England and Wales more than 204,000 hospital beds occupied by patients suffering from mental illness or mental deficiency. This figure can be compared with the 219,000 occupied beds for all other diseases put together. In addition, there were more than 81,000 mental defectives under some sort of supervision provided by the local authority and an unknown number of persons suffering from neuroses which impair their efficiency and happiness. This problem is increasing. In 1949, it led to the formation of the Mental Health Research Fund by a small group of scientists, doctors, and laymen who shared the belief that mental health and mental illness were not receiving that share of attention in research which their importance demands.

The Fund was registered in 1952 and heads of leading research institutions in Great Britain were invited to say in what ways they would wish to use any money that might be available for work in promoting mental health.

A conference at Oxford was then convened to which were invited a wide cross-section of scientists, ranging from anatomists to sociologists, as well as a number of practising psychiatrists and professors of psychiatry. Its terms of reference were to answer the following questions: What are the ignorances which to-day principally hamper understanding of the nature, prevention and cure of mental illness? What advances in research are most likely to remove these and so help to reduce the population of mental hospitals and institutions for delinquents?

The Fund has now defined its main purpose and responsibilities as follows: The establishment of research fellowships in the several fields of mental science; encouraging co-operation between workers in different fields of mental science by arranging conferences; supporting specific lines of investigation by providing technical assistance, expenses or equipment for research workers; and arranging for the exchange of information with workers in other countries by financing attendance at regional and international meetings.

To further these objectives, the Fund proceeded to collect money and make grants on an increasing scale. It was fortunate in receiving grants from the Ford Foundation, the Leverhulme Trust, the Peel Trust and the National Society for Mentally Handicapped Children, as well as valuable support from the general public.

The Fund has now well-established procedures for inviting and assessing applications for support. Every research centre in Great Britain has been informed of the Fund's interest, of the kinds of help it is able to offer, and receives annually its invitation to prospective applicants.

During 1957 the Fund planned and issued invitations to the international conference recently held in Oxford. The theme of this conference was the concept of stress; its main object was to elucidate the variations of this concept as used in psychiatry and to relate them to each other and to the somewhat different concepts of stress which are used in physiology. Information about the Fund may be obtained from 39 Queen Anne Street, London, W.1.

GLACIOLOGICAL OBSERVATIONS ON RUWENZORI

THE Department of Geography of Makerere College in the University College of East Africa has recently distributed a duplicated report* of eighteen quarto pages on the reconnaissance expedition to Mt. Ruwenzori conducted by four members of the College staff during December 28, 1957–January 12, 1958, under the leadership of Mr. F. P. Henderson, lecturer in geology. The object of the expedition was glaciological: it was hoped to make observations on some of the thirty odd glaciers of the mountain which would provide information as to their state during the International Geophysical Year. Oriented photographs were taken from marked sites of the highest peaks, Stanley Ice Plateau, and four or five of the principal glaciers; comparison with photographs taken by earlier expeditions reveals a general and considerable wastage of the Ruwenzori glaciers. In addition, a hut was erected above the snow line, a survey base was marked and measured, and from it the positions of a series of markers on the Elena glacier determined. Only one of several markers placed on this glacier by previous expeditions was discovered, and even this was useless since its original position could not be fixed.

It is concluded by the leader that relatively small expeditions of this type at fairly frequent intervals offer a more promising mode of attack on the problems of this mountain than do more elaborate expeditions widely spaced in time. Accordingly, it was planned to follow up the reconnaissance with a further expedition six months later. On June 23, *The Times* reported that this expedition, again under the leadership of Mr. Henderson, began the ascent of the mountain on June 10, but operations had to be given up on June 18 owing to the illness and death from pneumonia of Mr. William Dickins, lecturer in geography in the Department of Education. During the reconnaissance, one member of the expedition, Dr. Whittow, contracted bronchial trouble and retired from the mountain; and, indeed, high-altitude pneumonia is a well-known phenomenon on Ruwenzori.

The courage of the young men of these two expeditions in planning fairly regularly repeated observations on a mountain with such a notorious weather record and under conditions that allow of little time for acclimatization is wholly to be admired; but the tragic outcome of the second expedition leads one to express the hope that in future their plans may receive, in Government and university circles in Uganda, financial support sufficient to allow them to operate with larger margins and to permit the inclusion of a medically qualified member in the team.

DAVID L. LINTON

* Report of the Makerere College Ruwenzori Reconnaissance, December 1957 to January 1958. Pp. 18. (Kampala: Geography Department, Makerere College, 1958.)

ROLE OF TURBULENT SCATTERING IN LONG-DISTANCE RADIO PROPAGATION AT METRE WAVE-LENGTHS

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SOME controversy has recently arisen[1] in regard to the practical confirmation of the theoretical prediction[2,3] that a permanent mechanism of long-distance propagation of short radio waves will arise from scattering by randomly distributed irregularities of refractive index associated with atmospheric turbulence. Some recent experimental results which appear to confirm its presence at metre wave-lengths are now presented.

Following the series of metre-wave experiments recently described[4], further work was carried out by the Admiralty Signal and Radar Establishment in November and December 1957, in the English Channel area, using a ship-borne transmitter against a shore-based receiver near Portsmouth, on a frequency of 203·5 Mc./s. The transmitter and receiver were those used in previous experiments[4], but with the addition of a high-speed continuous recorder of received field-strength, of time constant 0·1 sec., and an automatic signal-level distribution analyser for the determination of the instantaneous amplitude distribution. The latter was operated for 3-min. sampling periods, comprising 1,000 individual signal samplings, for each of which the resolving time was 20 m.sec. The height above sea-level of the receiving aerial was 120 m. and that of the transmitting aerial was 12 m. The latter produced a radiation pattern in the vertical plane in which the lowest lobe was elevated at an angle of about $1\frac{3}{4}$° above the horizon. This has been allowed for in applying the theoretical treatments of the possible propagation mechanisms to the observed results. It is believed that this has no influence on the interpretation of the propagation mechanisms involved.

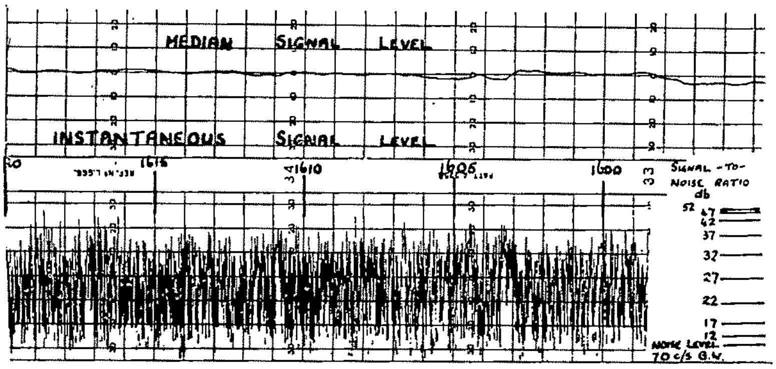

Fig. 1. Long-range propagation measurements, 203·5 Mc./s., December 11, 1957. English Channel area

Field-strength recordings were made for a number of outward runs by the ship, on a true bearing of 245°, for ranges of up to 350 nautical miles. Both the median level and the fading characteristics of the signal were carefully analysed. Further, the instantaneous signal amplitude distributions were obtained from the analyser data by plotting on normal and Rayleigh probability paper. A careful examination was made of the surface and upper-air meteorological data published by the Meteorological Office for the period concerned. Although no upper-air data were available for places nearer the transmission path than Camborne, Cornwall, on each of the particular runs to be discussed the meteorological situation was the same over a wide area surrounding the transmission path, as evidenced by the charts for the various fixed levels and the close similarity of upper-air conditions at Camborne and more distant stations such as Crawley and Valentia.

On each of the three runs made by the ship during the period November 25–29, involving ranges between 110 and 250 nautical miles, the characteristics of the received signal field were very similar, and of a type familiar from previous experiments (ref. 4, type 'B'). The fading was of the 'roller' type: broad flat maxima separated by deep sharp minima, over a range of 20–30 db., and of period 1–5 min. On each run the transmission path lay in the central regions of a persistent anticyclone. It is well known that subsidence normally occurs at upper levels in these conditions, and across the boundary between the subsiding air and the surface layer there will occur both a rapid increase of temperature and a rapid decrease of water-vapour content, giving a thin layer of sharp decrease of radio refractive index. The upper-air meteorological (radio-sonde) data confirm the existence of such a layer, at a level of about 1,500 m., at all the above-mentioned stations. It is difficult to make quantitative estimates of the partial reflexion of the incident wave which will occur at this layer, since the available upper-air data are too coarse to permit its thickness, or the form of the variation of refractive index within it, to be determined. The reflexion coefficient of the layer decreases rapidly if its thickness $t > t_0 = \lambda/4\pi\alpha$, where λ is the radio wave-length and α the angle of incidence on the layer. For the experiment under consideration, the maximum value of this critical thickness t_0 is 15 m. at 110 nautical miles total range, decreasing to 6 m. at 250 miles. However, there is some evidence that inversion layers caused by subsidence in anticyclones can have thicknesses not greatly exceeding these values; this seems reasonable, since under conditions of anticyclonic subsidence wind speeds are small and the temperature lapse-rate is stable, so that turbulence is weak. Although the form of the variation of refractive index within the layer is still unknown, it seems reasonable to assume that the radio transmission was primarily due to partial reflexion from the layer, and this hypothesis is consistent with the fading characteristics of the received signal. The observed median signal-levels were considerably higher (usually 30–50 db. below free space at the shorter ranges, and 50–70 db. below at the longer ranges) than those which scattering theory[3] predicts, particularly since, as already mentioned, the intensity of turbulence was likely to be less than usual. The meteorological data confirm directly that the upper winds were very light and the temperature lapse-rate small. Thus, a contribution from scattering to the received signal would be negligible, by comparison.

However, the results of the run made on December 11–12 were completely different. Throughout this run, which covered the range interval from 140 to 260 nautical miles, the received signal suffered extremely rapid fading (Fig. 1), at a rate of about 30 cycles per minute. The observed median signal-level showed a slow and fairly uniform attenuation with range; its levels at 150 and 250 nautical miles range were respectively about 75 and 90 db. below the free-space values, corresponding to a mean rate of attenuation of 0·15 db./mile. These values are all in good agreement with predictions made from turbulent scattering theory[3]. During the whole of the run the transmission path lay within an air stream which is shown by the upper-air data, and by the development of convective type cloud and showers, to have been unstable, up to at least 7 km. height. Strong turbulence would thus be expected over the most important part of the scattering volume. Further, this instability and turbulence would be likely to preclude the formation of stratified layers, especially of thickness small enough to give appreciable partial reflexion. No inversion layers were apparent in the refractive-index–height distributions constructed from the upper-air data.

Further, the rate of fading observed is in excellent agreement with predictions from scattering theory[5], but would be difficult to explain on the hypothesis of a reflexion mechanism. The instantaneous signal amplitude distributions were close to the Rayleigh form which would be expected for a random scattering process, except in certain cases when significant changes of the mean signal-level were shown by the records to occur during the period of sampling. In the latter cases the distribution of signal amplitude tended towards a log normal form, as would be expected. While a Rayleigh-distributed received signal could also be caused by the addition with random phases of a limited number of signal components reflected at discrete inversion layers, as recently suggested[6,7], this is open to the serious objection, already mentioned, that the strong turbulence present on this occasion made the existence of such thin layers extremely unlikely.

It is therefore suggested that all the evidence points to turbulent scattering as the dominant propagation mechanism on this occasion. Further, since, on both theoretical and experimental grounds[3], it seems that turbulence to some degree must almost always be present at all levels in the troposphere, it may be concluded that the scattering mechanism will be similarly permanent. It will, of course, be frequently masked by the stronger mechanism of partial reflexion, but can only be neglected for purposes for which only occasions of unusually strong transmission are of interest.

The work described is published by permission of the Admiralty. We desire to acknowledge the assistance of Messrs. I. J. Richmond and W. L. Hibbens in the preparation of the experimental equipment and in the conduct of the observations.

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PROTECTION OF LIVING CELLS AGAINST ACID BY CERTAIN NON-IONIC AND AMPHOTERIC SOAPS

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IT is reported that the interior of phagocytic cells is, or can become, acidic[1], but it is undecided how far this property might contribute to the destruction of certain bacteria ingested by them[2]. Tubercle bacilli can survive and multiply within these cells, or be inhibited in growth or destroyed, according to circumstances[3]; this bacterial species is well known to be relatively resistant to acid, though the resistance is far from absolute[4]. Certain non-ionic soaps, namely, certain polyoxyethylene ethers, which are without apparent effect on the multiplication of tubercle bacilli *in vitro*, exercise a strong effect *in vivo*—some suppressing and others enhancing experimental tuberculous infection; their site of action is considered to be within the monocytic phagocytes[5–8]. It was therefore of some interest to examine the effect of these agents on the resistance of tubercle bacilli to acid.

Preliminary experiments provided no simple explanation of the action of the agents on tuberculosis, but they revealed a general phenomenon which forms the subject of this article. The experiments have been extended to include exposure of other bacteria besides *Mycobacterium tuberculosis*, as well as of human red blood-cells, to acid in the presence and absence of various non-ionic soaps and other compounds.

Suspensions of micro-organisms were obtained from cultures on solid nutrient medium. The reaction mixtures contained usually 1 *M* or 0·1 *M* hydrochloric acid (to give a final measured *p*H of 0·6 or 1·2, respectively), or 0·1 *M* citrate buffer (to give *p*H 3·5, 5·0 or 7·0), or no buffer (*p*H 7·0); a non-ionic soap 1·25 per cent w/v; albumin 0·025 per cent; micro-organisms 10^6–10^7/ml.; total volume 4·0 ml. The mixtures were incubated in 25 mm. diameter test-tubes at 37° C. for 3½ hr., with intermittent shaking by hand. After neutralization, viable counts were made on nutrient medium from 0·02 ml. drops of suitable dilutions. Human red blood-cells were suspended in 0·13 *M* sodium chloride containing 0·03 *M* acetate buffer at a final *p*H of 3·5 and upwards; and the extent of hæmolysis during 3 min., in the presence or absence of the test substance, was noted.

Table 1 shows tests of the effect of non-ionic soaps and other substances, including the phospholipid lecithin, against the lethal action of acid solutions on *N. tuberculosis*. Somewhat surprisingly, all the non-ionic soaps tested (including saponin and polypropylene glycol) are able to protect the bacilli against acid. Even more interesting is the observation that the amphoteric soap lecithin acts similarly. Soaps able to suppress experimental tuberculosis ('Triton *WR*1339') are just as effective as those that are pro-tuberculous (*HOC*-60). Other molecules of similar size but possessing no soap-like activity, for example, polyethylene glycol, sucrose and suramin, were unable to protect.

The protective action of the soaps was next tested with another species of *Mycobacterium*, with three other species of bacteria normally less resistant to acid, and with human red cells. Table 2 shows that the killing of the various bacterial species by acid is also impeded by a typical member of the soaps, though at a different *p*H from that with *M. tuberculosis*. The hæmolysis of red cells by acid is considerably delayed in their presence.

Very approximately the effect of the soaps is to increase the concentration of hydrogen ions required for rapid destruction one hundredfold, that is, a shift of 2 *p*H units. The soaps do not appear to confer complete protection against the bactericidal and hæmolytic effects of acid: their action is to reduce considerably the rate at which damage occurs. In this connexion the bacteriostatic action of weakly acid solutions (*p*H 5–6) upon tubercle bacilli is not prevented by the soaps. Under otherwise identical

Table 1. Lethal Action of Acid on Tubercle Bacilli (Strain *H37Rv*) with or without various Non-ionic Soaps, etc.

Substance	Concentration (per cent w/v)	Survivors (viable units/0·02 ml.) after exposure for 3½ hr. at 37° C. at *p*H: 0·6	1·2	3·5	5·0	7·0
Control without soap	—	< 1	1	30	10,000	10,000
'Triton *WR*1339'*	1·25	< 1	6,000	8,000	10,000	10,000
HOC-60 (*GN*/102)*	1·25	< 1	7,000	—	7,000	—
HOC-75 (*GN*/104)*	1·25	—	—	8,000	—	—
Saponin	1·25	< 1	3,000	—	—	10,000
Polypropylene glycol M.W.425	1·25	< 1	1,000	—	—	10,000
Lecithin (egg)	1·0	—	6,000	8,000	—	8,000
Polyethylene glycol M.W.600	1·25	—	< 1	—	—	10,000
Suramin	1–10	—	< 1	—	—	10,000
Sucrose	1–50	—	< 1	—	—	10,000
Glycerol	5–50	—	< 1	—	—	2,000
		Survivors after exposure for 24 hr.				
Control	—	—	< 1	< 1	—	10,000
'*WR*1339'	1·25	—	850	7,000	—	10,000

* 'Triton *WR*1339' is a polyethylene glycol ether of a *p-tert*-octylphenol-formaldehyde linear polymer; *HOC*-60 and *HOC*-75 are polyethylene glycol ethers of a *p-tert*-octylphenol-formaldehyde cyclic tetramer (with average 60 and 75 ethylene oxide units per phenolic group) (ref. 5).

Table 2. Lethal Action of Acid on various Cell Species with or without 'Triton *WR*1339'

Cell species	Survival after exposure* at *p*H: 1·2		3·5		5·0		7·0	
	Control	Soap	Control	Soap	Control	Soap	Control	Soap
Myco. tuberculosis (*H37Rv*)	1	6,000	30	8,000	10,000	10,000	10,000	10,000
Myco. phlei	< 1	< 1	2	75,000	—	—	75,000	75,000
Staph. pyogenes	< 1	1	3	20,000	—	—	100,000	100,000
Esch. coli	< 1	< 1	< 1	< 1	—	—	80,000	80,000
Strep. viridans	< 1	< 1	< 1	< 1	3,000	50,000	50,000	50,000
Human red cells	—	—	0	100	100	100	100	100

* For the bacteria, survival is indicated by the viable units/0·02 ml. remaining after exposure for 3½ hr. at 37° C. For the red cells, survival is indicated by the percentage of intact cells remaining after exposure for 3 min. at room temperature.

conditions to those listed, similar protection of tubercle bacilli against the acids perchloric (0·1 M to give a final *p*H of 1·2) and phosphoric (*p*H 3·5) was observed. No protection by the soaps against the harmful effects of exposure to alkali has been detected.

So far, we have insufficient evidence to offer an explanation of the mechanism of the protective action of these soaps. There exists, however, a parallel between the protective action and their ability to discharge the colour of fluorescein and similar dyes in acid solutions[9], and this may provide a clue towards the understanding of their action. The failure of solutes such as polyethylene glycol and sucrose to protect would suggest that the protective activity of the soaps is not simply a consequence of the osmotic pressure of their solutions, but rather some specific effect connected with their soap-like properties.

If the phenomenon here reported should be associated with a wide variety of living cells, it might find practical application in certain situations where a temporary and limited protection of cells against acidity is required.

We are indebted to Messrs. Bayer Products, Ltd., London, for supplying 'Triton *WR*1339', and to Dr. J. W. Cornforth and Dr. G. A. Nicholls for preparing the two soaps of the *HOC* series.

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DISTRIBUTION OF ANTISTREPTOLYSINS IN PROTEIN FRACTIONS

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THE relation of immune substances to single protein fractions has been the subject of extensive studies. The recognition of the method of paper electrophoresis by Durrum[1], Grassmann and Hannig[2] and Bockemüller and Rebling[3] and the method of immuno-electrophoresis by Grabar *et al.*[4] has opened new roads in this field. Although the investigations were very extensive, no direct determinations have been published, to our knowledge, concerning the distribution of antistreptolysins in the protein fractions. The method I had formerly employed in studies on the combination of bactericidal agents with protein fractions proved to be very suitable for use in the investigations concerned with the combination of antistreptolysins with those fractions[5].

In studies on the antistreptolysins linked to serum proteins the method has been modified in that the agar was dissolved in a veronal buffer of *p*H 7·4, and to this were added 1 per cent fresh, thrice-washed sheep erythrocytes. The paper strips containing the protein moved by electrophoresis were placed on them. After paper strips had been cut up and put in place, a streptolysin-0 standard (generously supplied by the Behringwerke, Marburg) dissolved in sodium thioglycollate buffer and containing 20 units per ml. was applied to the paper. This was done by placing a platinum loop full of streptolysin-0 solution on the paper at intervals of 30–35 min. over a period of 4–5 hr. In the intervals the plates were incubated at 37° C. in an incubator to promote the reaction. The results were read 8–10 hr. after the placing of strips and beginning of streptolysin administration. The areas showing hæmolysis after the removal of the paper strips were observed, distinguishing two grades in hæmolysis : total inhibition, when there was no lysed area under the paper ; and partial inhibition, when both hæmolysed and non-hæmolysed areas were detectable. The other half of the electrophoretized paper served as the control and after staining was studied by densitometry in an Eppendorf photometer. The extinction values were plotted as a curve. The inhibition of hæmolysis was marked at the appropriate site of the curve and thus the effect of antistreptolysin could be determined accurately.

Sera from normal human subjects and rabbits, as well as from patients showing high antistreptolysin titres (M.I. titre, 1 : 1,100 ; T.E. titre, 1 : 720) were used. The electrophoretic curves and the corresponding antistreptolysin effects are shown in Figs. 1, 2, 3 and 4.

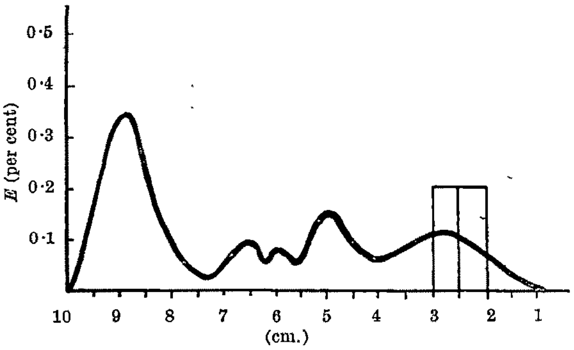

Fig. 1. Normal rabbit serum

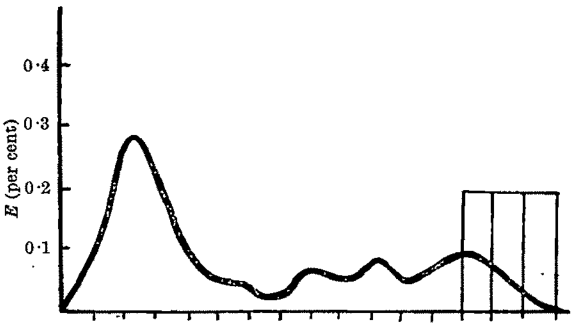

Fig. 2. Normal human serum

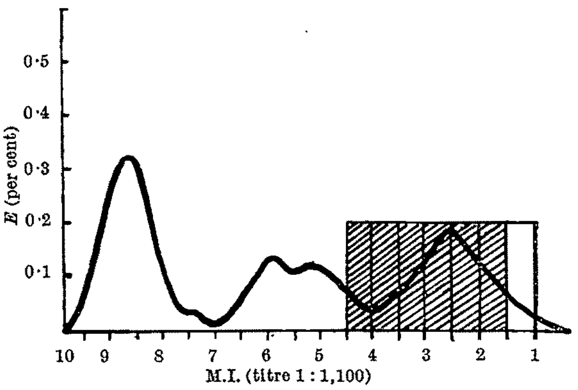

Fig. 3

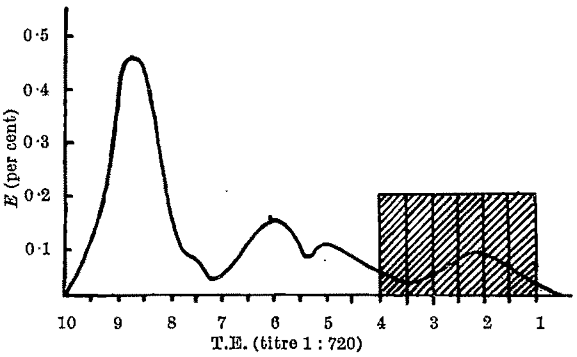

Fig. 4

The columns indicate inhibition of hæmolysis. The shaded columns show total inhibition, the empty ones partial inhibition. It is shown by Fig. 1 that the antistreptolysin effect of normal rabbit serum (titre 1 : 10) is bound exclusively to gamma globulin. The main mass of gamma globulin carries this activity, and this lysin inhibition is absent in the ascending and descending branches of the curve. The effect, however, manifests itself in a partial inhibition only. The normal human sera showing antistreptolysin titres as low as 1 : 100 had the same effect (Fig. 2). Here, too, it was exclusively in the area corresponding to the main mass of gamma globulin that an inhibition of hæmolysis, the manifestation of the antistreptolysin effect, was observable. Here, too, inhibition was only partial.

In contrast with this, the high-titre human sera from patients suffering from streptococcal infection behaved quite differently. First of all, the effect was more intense, in so far as here inhibition proved to be complete. Another remarkable finding was that inhibition could be observed also outside the main mass of gamma globulin, in the areas containing a very low concentration of protein migrating faster than gamma globulin. This area of the electrophoretic curve is what is called the area of the fraction *T*. In this area, too, the effect was substantially more marked than in the case of normal sera. A comparison of the curves for the two pathological sera shows a remarkable difference in the gamma globulin-level between the two sera. Although this was very marked, the two sera did not differ substantially in antistreptolysin titre or in the results concerning the fractions studied (Figs. 3 and 4).

These investigations appear to prove beyond doubt that the immune bodies, at least so far as the antistreptolysins are concerned, differ from the normal gamma globulins. Although no data are available as to their other physical properties, it appears to be unquestionable that these immune bodies migrate at a faster rate than the main mass of gamma globulin. This kind of gamma globulin does not make the immunological significance of gamma globulins questionable, but its existence seems to confirm those experiments in which the immune bodies have been found to be linked not exclusively to gamma globulin[6–8].

Rantz, Rendall and Rantz[9], Imperato[10] and others have reported that a close correlation exists between the level of gamma globulin in serum and the antistreptolysin titre of serum in diseased adults and children. The increase in gamma globulin in such patients can be ascribed to the inflammatory phenomena associated with streptococcal infection and the secondary tissue destruction, rather than to the antistreptolytic activity of sera in such patients. The two curves of the patients offer a strong confirmation of this view, in so far as the immunoantistreptolysins act not only in the area of the gamma globulin but also beyond the main mass of gamma globulin, in the initial part of beta globulin. Considering the amount of serum applied to the paper and the dissociation resulting from migration, it is obvious that only traces of protein can be involved in the effect. This will be even more conspicuous if we take into account also the protein concentration of the interspace between gamma and beta globulin. If we assess planimetrically and by computation the amount of protein contained in the active area on the basis of the quantity of serum applied to the paper (10 mm.^{3}), it will be found that the protein in the interspace between the two fractions corresponds to 1·8 gamma total protein in the case of M.I. and to 0·7 gamma in the case of T.E. This shows clearly how highly active these substances are. Such a high activity is common to the immune reactions in general.

Thus, the experiments with streptolysins have proved beyond doubt that the normal antistreptolysins are different from the immune antistreptolysins, as manifested particularly in a difference in the rate of migration. On the other hand, such minute amounts of protein may suffice to produce a manifest immune effect as cannot be demonstrated in many a case by the highly sensitive reactions, either.

The antistreptolysin studies showed that the antistreptolysin effect of normal human and rabbit sera corresponded to the main mass of gamma globulin. On the other hand, high-titre sera from patients had a very marked effect not only in the area of the main mass of gamma globulin, but also in that between gamma and beta globulin. This evidence suggests that there are apparently two kinds of antistreptolysin, one of which migrates definitely linked to gamma globulin. This occurs in normal sera. The other is an immune body migrating with, and also faster than, the main mass of gamma globulin. This occurs in pathological sera as a result of immunization. The high activity of the substance is shown by the fact that the effect develops also in the presence of very small amounts of protein, as small as 1·8 and 0·7 gamma.

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SPATIAL SUMMATION FOR HEAT-PAIN

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THE experiments of Hardy, Wolff, and Goodell[1], using the radiant-heat technique of focused stimulation, and varying the size of skin surface area exposed to stimulation, showed no threshold variation for pain relative to size of skin area within a range from 0·95 to 28 cm^2. Warmth thresholds were, however, shown to increase more than 200-fold as the area of skin stimulated was diminished from 200 to 0·2 cm^2. The authors therefore concluded that the only cutaneous sensation which does not possess this property is pain, thus distinguishing pain functionally from other sensations, and lending support to their thesis that pain is a sensory modality subserved by a special neural equipment.

Weddell and his associates[2–3], in supporting a 'pattern' theory of non-specific representation in cutaneous sensibility, have put forward two reasons why the evidence refuting spatial summation for pain is not conclusive: (1) Breig[4] is said to have demonstrated spatial summation for the pain caused by drawing a pin across the skin; (2) it has been shown, using a dolorimeter constructed in a manner similar to that of Hardy *et al.*, that there is a 50 per cent fall-off in the intensity of radiation from the centre to the periphery of a 9·6 cm.^{2} area, due to the construction of the filament of the lamp used as the source of radiant energy. Thus a cone of radiant heat is applied to the skin area, so that the heat is not uniformly disposed.

The question, therefore, of whether or not it is possible to demonstrate spatial summation for pain may have some crucial bearing on two major theories of sensibility to cutaneous pain.

In the present study, it was decided to use a water-heating system so as to avoid the technical flaw of the radiant-heat technique. This system consisted of two 4-gallon drums filled with water. The water of one drum was maintained at boiling point throughout the experimental sessions by two immersion-heater elements, the drum being encased with heat-insulating material. The other drum was filled with cold tap-water. A rubber tube was connected to an outlet from the lower part of each drum, the flow of water being regulated by a tap. The outflow of boiling and of cold water then merged together in a common pipe to a glass connecting tube at the open base of which a circular disk of brass shim, three-thousandths of an inch thick, was securely fixed with heat-resistant glue. A centigrade thermometer was set into the top of the glass connecting tube, standing perpendicular to the horizontal circular disk and with the tip of the mercury bowl almost in contact with it, the rest of the bowl being completely immersed in the hot water. The continuous merging flow of water from the two drums was regulated by the taps until the desired reading on the thermometer was steady.

For the purpose of this experiment, two sizes of circular metal disk were fitted to otherwise identical glass connecting tubes, the one being of 1 cm. and the other of 2 cm. diameter. These disks served as the heat-stimulus contacts for placing on the skin of the volar surface of the subject's left forearm.

Eight adult subjects took part in the experiment, none having prior knowledge of its specific purpose. Each subject was tested on four separate sessions of 45 min., each session being divided into two half-sessions, during one of which the 1 cm. contact was used, and during the other the 2 cm. contact. The order of presentation of the 1 and the 2 cm. contacts was alternated, so that, on sessions one and three, four subjects received the 1 cm. contact stimuli first, and the 2 cm., after a 5-min. interval, during the second half-session; on sessions two and four these subjects received the 2 cm. first and the 1 cm. after the interval. The order of presentation was reversed for the other four subjects. This alternation was intended as a procedural control for any possible serial effect.

The subject was blindfolded before entering the experimental room, so that he could receive no cues from viewing the apparatus. He was instructed to report simply the quality and intensity of the sensation that he experienced during the 3 sec. of exposure of a heated metal contact on his skin. He was given no clue that the metal contacts would differ in size, and he was asked to try to grade the sensations in terms of warmth, heat, pain or no pain, and to retain, as best he could, a consistency in his judgments throughout all the experimental sessions.

The metal contact, attached to a lever, was automatically lowered on to the skin for the 3 sec. exposure period by means of a timing device operating an electromagnet and armature. Until just prior to the 3 sec. period, the contact was kept at a distance of 8 in. above the subject's forearm. It was then lowered to 3 mm. above the skin, a cardboard screen of that thickness being placed between the contact and the skin. This screen was withdrawn immediately prior to the automatic lowering of the contact, which thus fell with a light pressure on the skin, remained there for 3 sec., and at the end was jerked 3 mm. away from the skin and then a further 8 in. above. The minimum interval between successive exposures was 75 sec., and the skin surface area exposed was varied over a distance of 10 cm. longitudinally and 4 cm. laterally. Between 6 and 10 stimuli of varying heat-intensities were applied at each contact-size, and an interval of 5 min. was allowed between the half-sessions, ostensibly as a 'rest' period for the subject during which he went to an adjoining room but in fact to enable the contact-size to be changed. Each subject thus received a total of about 30 heat-stimuli at each contact-size.

The procedure used to arrive at an appropriate narrow range of heat-intensities at, just above, and below the subject's pain threshold was to begin each half-session with a stimulus estimated to fall 2–3° C. below pain threshold. If the sensation reported was of warmth or heat, with no pain, the intensity was increased by steps until pain was first reported. Then stimuli were presented which were close to this 'standard', and an occasional 'check' stimulus at expected 'warmth' intensities only were interspersed to test the reliability of the reporting. It immediately became clear, however, that the intensities required to elicit pain at the 1 cm. size were likely to be several degrees higher than for 2 cm. Skin temperature was continuously recorded from a thermistor placed on the volar surface of the right forearm, but no significant changes were observed in any subjects as between the 1 and 2 cm. test sessions, and there was very little intra-individual variation once the 'steady' level had been reached. Thus differences in skin temperature do not account for the results reported below.

The present stimulation technique was so arranged that the metal contact fell with a light pressure of identical *total* weight for the 1 and 2 cm. sizes. It was thus possible that the difference in pressure per unit area might affect the subjects' reports. For three of the eight subjects, therefore, the 1 cm. contact was fitted with a 'Perspex' ring, making the total contact area on the skin identical to that of the 2 cm. disc. The results obtained with this variation were so closely similar to those obtained on the other five subjects that they have been grouped with these. By placing thermocouples on the contact side of the metal and on the 'Perspex' ring it was found that the latter heated up to a maximum of 36° C. when the metal contact had been maintained for 20 minutes at 50° C.

With this technique and procedure, the results demonstrate consistently and highly significantly

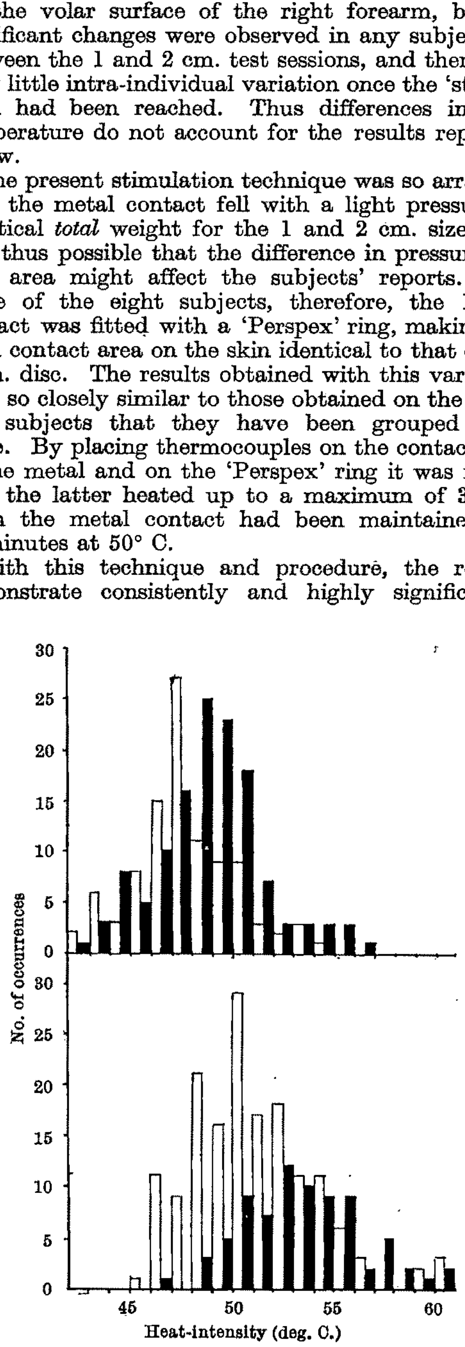
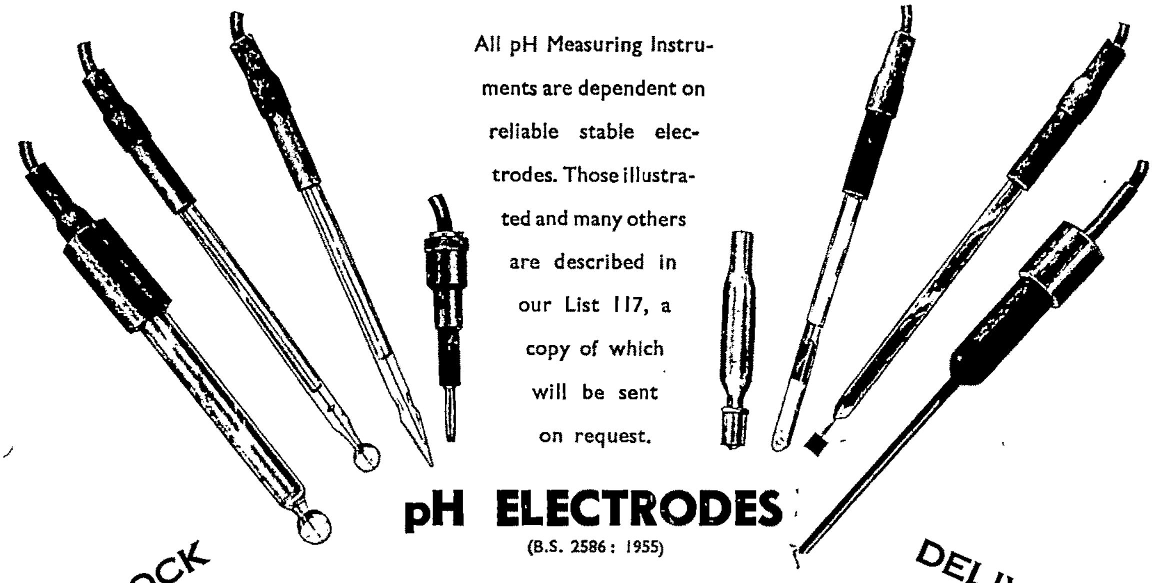


Fig. 1. Histograms showing frequency of occurrence of pain reports (black columns) and no-pain reports (unshaded columns) at various heat-intensities with 2 cm. (upper diagram) and 1 cm. (lower diagram) disks



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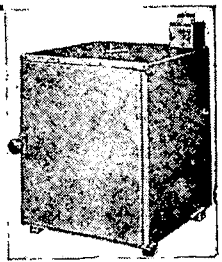

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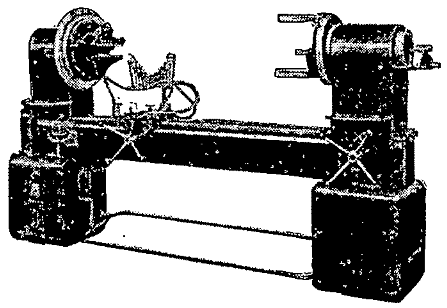

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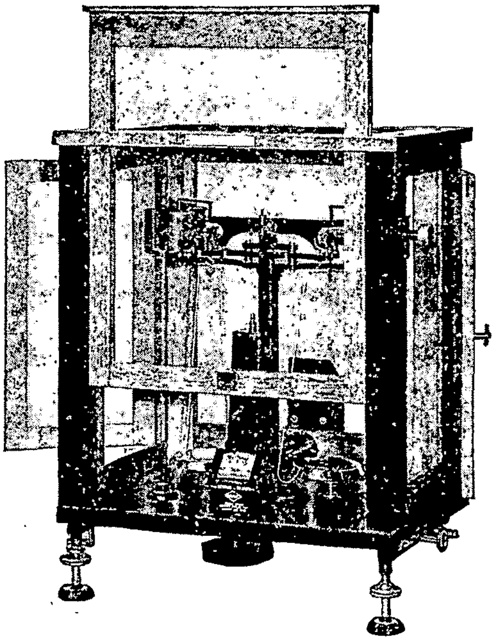

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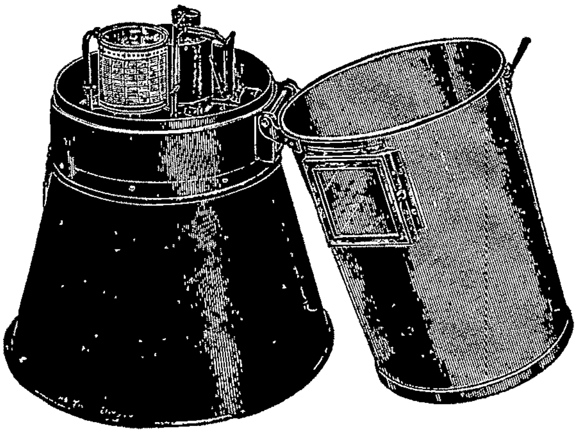

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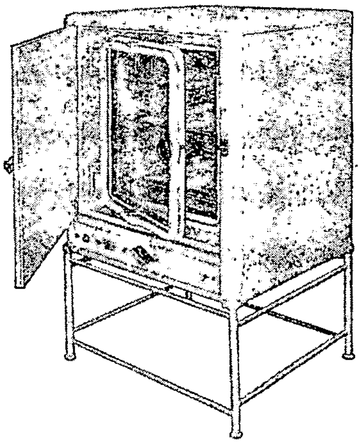

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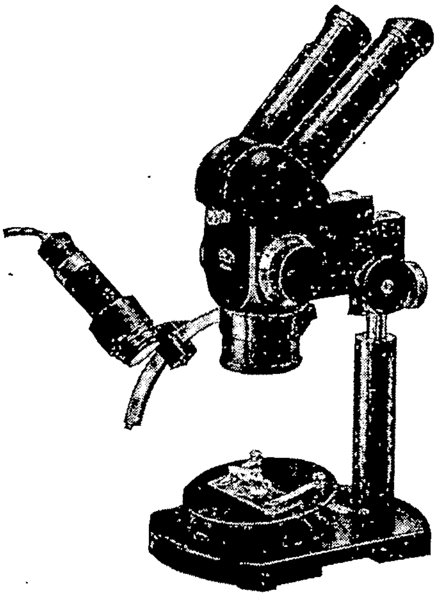

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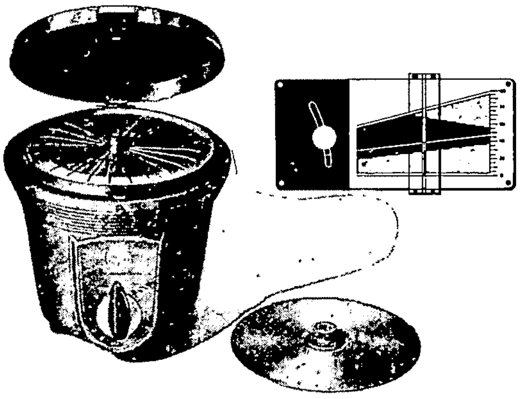

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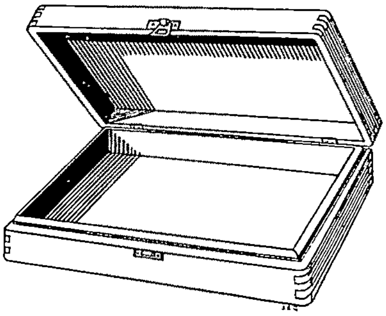

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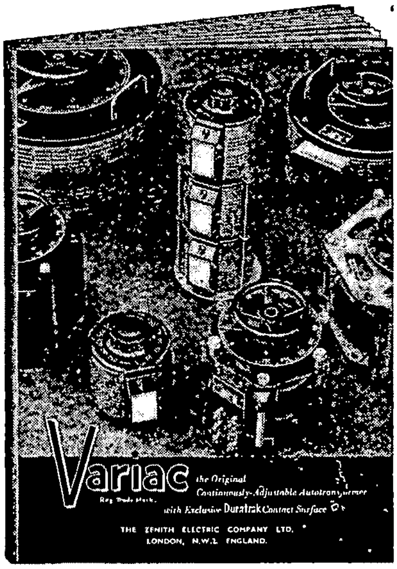
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that there is a spatial summation for heat-pain. The reports made by the eight subjects for the 1 and 2 cm. contacts are summarized in the histograms of Fig. 1, the black columns representing the frequency of reports of pain at the various heat-intensities used, the unshaded columns that of the reports of warmth or heat with no pain.

It will be seen that the frequency of pain-reports over the same range of heat-intensities is considerably greater for the 2 cm. application. Thus if we compare these frequencies over the range from 45·0° C. to 51·9° C., we find pain reported 104 times out of 186 observations (56 per cent) for 2 cm. and only 25 times out of 129 observations (20 per cent) for 1 cm. The χ^2 value of this comparison (42·1) corresponds to $P \leqslant 0{\cdot}001$.

The consistency of the difference is further emphasized by the fact that seven of the eight subjects reported pain at a lower heat-intensity for the 2 cm. contact on each of their four experimental sessions, the eighth subject once only reporting pain at slightly higher intensity for this contact than for 1 cm. Thus, on 31 out of 32 sessions the threshold for pain was lower with the 2 cm. than with the 1 cm. contact. The mean difference between the 1 cm. and 2 cm. pain thresholds for all the sessions was − 5·0 deg. C.

It would seem, therefore, that spatial summation is as clearly demonstrable for cutaneous heat-pain sensation as it is for other cutaneous sensations, so that in this respect pain can no longer be functionally distinguished from these other sensations. It remains, however, to show the spatial limits within which summation takes place and the exact relationship between heat-intensity and size of area stimulated in this way. It will be necessary also to inquire further into the perceptual aspects of spatial summation, for it is of some interest to record that none of the eight subjects at any time reported awareness of a size-difference between the contacts.

I wish to thank Mr. J. G. Taylor for his suggestions on the apparatus used in this study and Mr. P. Humphris for his careful attention to and skill in dealing with the technical aspects of the research. I am indebted to the Staff Research Fund of the University of Cape Town for a grant towards the cost of the apparatus.

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ROLE OF ROOT INJURY IN PANAMA DISEASE INFECTIONS

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THE *Fusarium* wilt of bananas, commonly called Panama disease, remains one of the major obstacles to be overcome in the cultivation of Gros Michel bananas in the western hemisphere. Although extensive investigations of this malady and its causal agent, *Fusarium oxysporum* f. *cubense* (E. F. Smith) Snyder and Hansen, have been carried out during the past half century, there is no general agreement as to the means by which the fungus enters the host plant. It is generally acknowledged[1] that infection does not occur by way of the pseudostem or the leaves, but it has been suggested[2] that penetration may occur through cuts on the rhizome or true stem. Wardlaw[3], however, has reported that under favourable soil conditions histological reactions within the rhizome tissues prevent significant penetration of the disease organism. In an early description of Panama disease, Brandes[2] presented evidence for penetration through intact tissues of main or primary roots close to the root apex. Wardlaw was unable to obtain root penetration in healthy active roots, but reported infections both of main roots and of lateral rootlets under conditions unfavourable for their active growth[4] or following plasmolysis[5]. He also observed fungus penetration into young main roots decapitated near their tips and studied invasion of trimmed root bases which in some cases led to actual rhizome infections. He considered trimmed root bases, together with insect injuries of the rhizome, as the major sites of infection. More recently Rishbeth[6] described healthy lateral rootlets as the major infection site, and indicated that penetration does not occur directly through the main roots in any circumstances. Finally, Stover[7] has reported that, in agreement with Rishbeth's findings, invasion in Nature occurs at or near the root-cap of lateral rootlets.

In view of the disagreement in the literature, this problem was re-examined here. As experimental material, young Gros Michel banana plants, grown from small seed pieces, were used. Plants to be studied were grown in large clay pots of soil or vermiculite, in root observation boxes having one glass side which was removable, or in a moist chamber. Experimental inoculations were made with three morphologically distinct isolates of *F. oxysporum* f. *cubense* which proved to be equally pathogenic under the conditions used. In some experiments an agar suspension of spores was applied to the roots, and in other cases spores were incorporated into freshly sterilized soil in which the plants were afterwards grown. Infections were studied only in the roots and were identified by the characteristic red or yellow discoloration of the vascular tissue. In all experiments, the pathogen was re-isolated from tissues suspected of infection. Histological studies were made on fresh material by means of hand sections, with supplementary evidence provided by serial sections prepared according to standard procedures[8].

An initial attempt was made to study possible direct infection of main roots as described by Brandes[2]. A heavy spore suspension in molten agar was applied to root surfaces both at the growing tip and in mature regions. No penetration was observed,

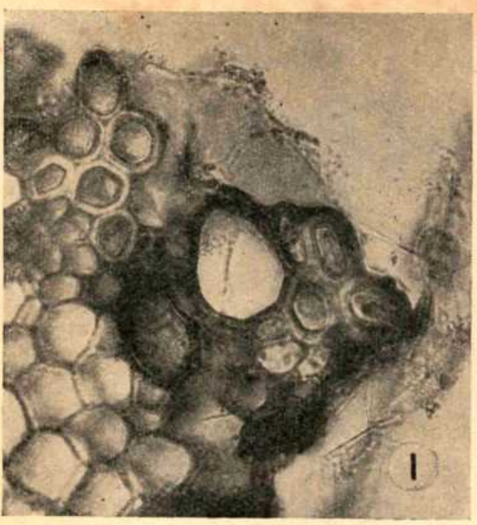


Fig. 1. Transverse section of a main root of a banana plant cut in the region of a deep lateral gash. A suspension of *Fusarium* spores in agar had been applied two days earlier. Hyphæ are visible both inside and outside the exposed vessel (× 275)

and the pathogen gave no evidence, in these experiments, of an ability to attack living cells of the main root. The roots used were growing in sterilized soil and were apparently healthy and vigorous. When, however, injuries were made prior to inoculation, the results were quite different. If in the region of mature tissues a deep lateral gash was made with a scalpel in such a way as to cut the vascular tissues and expose the xylem vessels, rapid (two days or less) penetration of the pathogen into the vessels was observed (Fig. 1). The same result was obtained whether the injury was treated with a spore suspension or whether the roots were merely growing in artificially infested soil (see Table 1). A similarly rapid penetration resulted from needle punctures or scalpel cuts before inoculation, provided that the vascular tissue was involved in the wound. It is interesting to note that shallow gashes or other wounds which did not reach the vascular tissue did not permit entry of the fungus. A layer of cortical parenchyma only two or three cells in thickness appeared to prevent infection completely, further substantiating the earlier observations of the inability of the fungus to attack living cells of the main root. Severing the main root in the mature region also provided a favourable site of infection, but the results were somewhat less consistent (Table 1). When lateral gashes or decapitations were performed in the immature regions of the root near the growing tip no penetration was observed. It remains to be determined whether rapid wound healing in this region is responsible for the failure or if some other factor, such as inability of the disease organism to penetrate immature vessels, is involved.

Table 1. PENETRATION OF WOUNDED MAIN ROOTS OF BANANA

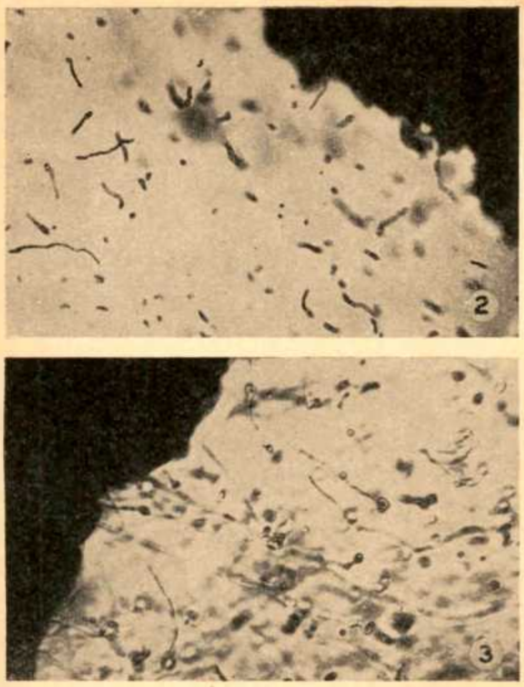
Type of wound	No. of roots Inoculated	No. of roots Penetrated
Spores in agar. Sterile vermiculite		
Deep lateral gash	9	9
Shallow lateral gash	3	0
Needle punctures	5	5
Knife cuts	5	5
Spores in agar. Sterile soil		
Decapitation near tip	7	0
Decapitation mature region	7	5
Deep lateral gash	9	9
Shallow lateral gash	3	1*
Deep gash near tip	2	0
Artificially infested soil		
Decapitation near tip	9	0
Decapitation mature region	8	3
Deep lateral gash	9	9
Shallow lateral gash	3	0

* Histological examination subsequent to the termination of the experiment showed a slight injury to the vascular system.

The importance of injury in *Fusarium* infections of main roots suggested that a similar condition might well prevail in lateral rootlets, in spite of earlier reports to the contrary. In preliminary experiments it has not been possible to establish with certainty the importance of injury primarily because the extreme fragility of lateral rootlets makes it almost impossible to eliminate injury in any experimental treatment. Experiments were conducted by applying a spore suspension in agar to rootlets, on a restricted region of a main root, or by studying roots growing in infested soil. Injury was produced artificially by clipping rootlets with scissors about midway along their length.

When spore suspensions were applied to supposedly unwounded rootlets, in many cases infection of the main root resulted in the region to which these rootlets were attached. Since, in general, there were no injuries of the main roots in these regions, it was concluded that penetration by way of rootlets does occur. However, as has been pointed out, it was not possible in these experiments to eliminate the factor of rootlet injury. It was quite evident that penetration was of much more frequent occurrence if the rootlets were deliberately injured by clipping. On the other hand, even such deliberate injury did not guarantee infection. The most striking observations were those made on plants growing in infested soil in root observation boxes. After large main roots bearing numerous laterals had developed adjacent to the glass side, this was removed with very little disturbance to the roots and on certain ones rootlets were clipped on one side only. The glass side was then replaced. Three weeks later the roots were removed and examined. Characteristic discolorations caused by the fungus were found only in those main roots the rootlets of which had been clipped and only on the side of the root to which these rootlets were attached. This evidence, while it clearly does not rule out penetration by way of intact rootlets, does suggest that injury may be an important factor in rootlet invasion. An extensive histological study of inoculated rootlets, both wounded and intact, did not reveal the presence of *Fusarium* hyphæ. This is in agreement with the observation of Rishbeth[6] that hyphæ are seen in rootlets only with great difficulty, and it suggests that although hyphæ probably are present in some cases, they do not ramify extensively through rootlet tissue.

In examining wounded main roots to which an agar spore suspension had been applied, a marked difference in extent of germination was noted between spores in proximity to the wounded surface and those in contact with an intact surface. There appeared to be a consistent stimulation of spore germination in the vicinity of a wounded root surface (Figs. 2 and 3). In order to verify the existence of such a stimulatory effect, a suspension of spores in agar was applied to wounded and intact main root surfaces on plants in a moist chamber. Control samples of the suspension were placed on glass slides in Petri dishes in the same laboratory room. When



Figs. 2 and 3. (2) Limited germination in the spore–agar inoculum after three days in contact with an unwounded root surface (right) (× c. 330). (3) Extensive germination and mycelial development in the same inoculum shown in Fig. 3 after two days in contact with a lateral gash on the main root. Note marked tropic response towards the wounded surface (left) (× c. 330)

spores from the three treatments were examined after twenty-four hours, it was apparent that germination had been markedly stimulated in proximity to the wound in comparison both with the control and with the intact root surface. Moreover, there was a definite inhibition of spore germination, as compared with the control, by the intact root surface. This observation is in striking contrast to the recent report of Jackson[9] that germination of spores of *Fusarium solani* was stimulated by the presence of intact seedling roots. A chromatographic analysis of the materials diffusing from injured banana roots revealed that the factors stimulating *Fusarium* germination and multiplication are amino-acids and, of these, glutamine appears to be the most important.

The observations reported in this article strongly suggest certain conclusions which may be of importance in future studies of Panama disease. In the first place, the current tendency to disregard the main roots as important infection sites must be re-examined in the light of clear evidence of the penetration of these organs when they have been injured. Secondly, the role of injury in Panama disease infections must be considered in all future investigations, not only as a condition making penetration possible but also as a source of influences which bring about a stimulation of the germination of *Fusarium* spores, thereby increasing the likelihood of successful penetration. In studies now in progress it is hoped to provide a critical evaluation of the importance of injury in the penetration of lateral rootlets by the fungus. Moreover, it will be necessary to determine the applicability of the observations reported here to banana plants growing in different circumstances and particularly under field conditions. The frequent occurrence of serious wounds in banana roots in the field, not only on lateral rootlets but on main roots as well, is certainly compatible with the concept of injury as a major factor in Panama disease infections.

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THE REARRANGEMENT OF EPINEPHRINE

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THE study of the enzymatic alteration of a metabolite logically starts from the knowledge of the nature of its electronic configuration and an appreciation of the chemical susceptibilities of the molecule. Such information provides a rational avenue for an investigation into the metabolic pathway. When this approach was applied in a study of the metabolic degradation of the catechol amines, an interesting possibility for a channel of metabolism emerged. I wish to report a rearrangement of epinephrine and norepinephrine of the pinacol–pinacolone type, leading to the formation of 3,4-dihydroxyphenylacetaldehyde. Since this aldehyde is a direct intermediate of 3,4-dihydroxyphenylacetic acid, one of the metabolites which has been reported to be a product from the incubation of norepinephrine with liver slices[1], this rearrangement may represent a chemical model for a further biochemical pathway of catechol amines.

Rearrangement of epinephrine and norepinephrine to 3,4-*dihydroxyphenylacetaldehyde.* To 200 mgm. of epinephrine or norepinephrine was added 3 ml. of 85 per cent phosphoric acid. (The reaction also proceeds with other strong acids such as 20 per cent hydrochloric acid.) The reaction mixture was heated rapidly to 125° C. for no more than 20 sec. and poured into 30 ml. of water. This solution was extracted twice with 10 ml. of ethyl acetate and the extract was washed with 5 ml. of water. The ethyl acetate of the extract was removed by evaporation with a stream of nitrogen. The residue (62 mgm.) was a clear, highly viscous oil which did not crystallize in the cold. This material was used for making derivatives.

The 2,4-dinitrophenylhydrazone of 3,4-dihydroxyphenylacetaldehyde was recrystallized from ethanol (melting point found, 169–70° C.; melting point lit. (ref. 2), 169–70° C.; analysis for $C_{14}H_{12}N_4O_6$ requires C, 50·60 per cent; H, 3·61 per cent; N, 16·86 per

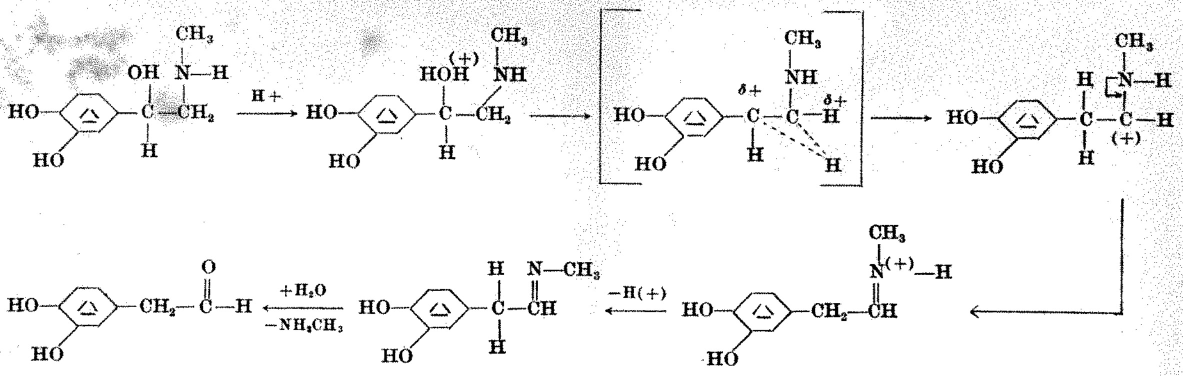

Fig. 1

cent: found C, 50·58 per cent; H, 3·76 per cent; N, 16·60 per cent.). The semicarbazone of 3,4-dihydroxyphenylacetaldehyde was recrystallized from ethanol/water (melting point found, 198–200° C.; melting point lit. (ref. 2), 199–200° C.).

Properties of 3,4-*dihydroxyphenylacetaldehyde.* This aldehyde appears to be quite stable when stored at − 15° C. It is very unstable in alkaline solution, rapidly turning brown then black to form complex polymeric products. It can be chromatographed on Whatman No. 1 paper in acid solvent, *n*-butanol/1·0 *N* hydrochloric acid, having an ascending R_F of 0·70. The catechol aldehyde exhibits the expected absorption peak in the ultra-violet at 280μ.

The effect of 3,4-dihydroxyphenylacetaldehyde on the isolated rabbit ileum and on the isolated uterus of the rat was determined using the methods described by Burn[3]. It was about 500–1,000 times less active than epinephrine in these systems. With 0·025–0·1 mgm. of the aldehyde per ml., marked relaxation of the isolated ileum and an inhibition of the contraction of the isolated rat uterus induced by acetylcholine was observed.

Holtz *et al.*[4] claimed that when urine, shown to contain oxytyramine, was incubated with tissue in the presence of oxygen a material was produced which had a depressor effect on blood pressure. They assumed that the depressor agent was 3,4-dihydroxyphenylacetaldehyde.

The material, prepared as described above, was tested for its effect on the blood pressure of a dog. The mean arterial blood pressure was determined with a mercury manometer connected to the cannulated femoral artery of animals anæsthetized with 'Nembutal'. Injections of as much as 24 mgm. 3,4-dihydroxyphenylacetaldehyde per 10 kgm. body-weight of the dog had no effect whatever on the dog's blood pressure.

From my observations on the lability of this material it is very unlikely that Holtz *et al.*[4] could have obtained it directly from incubation mixtures under the conditions which they described.

Rearrangement of ephedrine to phenylacetone. 100 mgm. of ephedrine sulphate was treated with 3 ml. of 85 per cent phosphoric acid at 130° C. for 2 min. The sweet odour of phenylacetone was readily apparent. The reaction mixture was poured into 30 ml. of 0·1 per cent 2,4-dinitrophenylhydrazine in 2 *N* hydrochloric acid. The derivative begins to form immediately. The precipitated hydrazone of phenylacetone was recrystallized from ethanol (melting point, 152–53° C. uncorrected; melting point lit. (ref. 5), 152–53° C.).

In 1860, Fittig[6] discovered that when the 1,2-glycol, pinacol, was treated with sulphuric acid, it underwent rearrangement to a ketone, pinacolone. Since that time a large number of substituted 1,2-glycols have been shown to undergo this conversion and reactions of this general type have become known as the 'pinacol–pinacolone rearrangement'.

The mechanism of this rearrangement has been extensively investigated and much has been learned about the aptitude of the various groups to migrate, the nature of the intermediate transition state of the molecule, and the effect of the character of substituent groups on the migrating species.

From the product of the acid-catalysed rearrangement of epinephrine, of norepinephrine, or of ephedrine, one may deduce that a similar mechanism will account for the carbonyl compounds formed.

In this case, as in the general pinacol–pinacolone rearrangement, a proton is added to the hydroxyl-group, which is thus eliminated as a water molecule, leaving a residual positive charge in the form of a carbonium ion. Simultaneously with its formation, the vicinal hydrogen is attracted, producing a positive charge on the adjacent carbon from which the hydrogen has migrated. This carbonium ion attracts electrons from its electronegative neighbour, the amino-group, to form, with a loss of a proton, the unstable imino-group. Hydrolysis of this group to the carbonyl-group takes place as shown in Fig. 1.

A similar explanation for the rearrangement of D-1,2-diphenyl-2-amino,1-anisyl ethanol has been advanced by McKenzie and Mills[7].

In the case of ephedrine either the hydrogen- or the methyl-group could migrate. Since phenylacetone alone was formed in this reaction it is clear that it was the hydrogen that migrated. This is consistent with the observations of other workers that the migratory aptitude of hydrogen is greater than that of any other group[8].

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Formation of Non-Enzymic Hæm

NEILANDS[1] has described the formation of coprohæm from iron and coproporphyrinogen in aqueous solution at physiological *p*H. Since uroporphyrinogen and coproporphyrinogen, rather than the porphyrins themselves, are now believed to be the true intermediates in the biosynthesis of hæm[2,3], it would be tempting to postulate that protoporphyrinogen is the intermediate which reacts *in vivo* with iron to form protohæm. Further to test this hypothesis, we have incubated aqueous solutions of coproporphyrinogen, coproporphyrin and protoporphyrin with ferrous salts under various conditions and have estimated the hæm formed spectrophotometrically as the pyridine hæmochrome.

Coproporphyrinogen ($1–2 \times 10^{-4}$ *M*) after 16 hr. incubation at *p*H 6 and 37° C. in the presence of large excess of ferrous ions ($1–5 \times 10^{-2}$ *M*) formed a small amount of coprohæm: less than 10 per cent when incubated under nitrogen and much less when incubated in air. However, starting from coproporphyrin, we found up to 25 per cent formation of coprohæm on incubation for 16 hr. at 37° C. under nitrogen and up to 12 per cent on incubation in air. At 100° C. in air the yields from both coproporphyrin and coproporphyrinogen were high and approximately the same. The porphyrinogens are readily oxidized to porphyrins by atmospheric oxygen and the coproporphyrinogen solutions always contained some coproporphyrin, even in those experiments in which incubation was carried out under nitrogen. It cannot be excluded that the formation of hæm observed when coproporphyrinogen was incubated with ferrous iron was derived, in fact, from coproporphyrin.

Protoporphyrin incubated with ferrous salts under the same conditions as were used for coproporphyrin was precipitated from solution and gave no detectable protohæm, but when native globin was added in order to solubilize the porphyrin there was an appreciable formation of hæm (up to 10 per cent with about 10^{-4} *M* porphyrin and 10^{-2} *M* ferrous iron). 'Teepol' (sodium alkyl sulphates) was even more effective; it held both the porphyrin and the ferrous iron in solution at all *p*H values in the range of neutrality (Phillips has used various detergents in order to measure the spectra of porphyrin esters in aqueous media; unpublished work). The yields of protohæm varied from 20 to 45 per cent over the *p*H range 5–8.

A high degree of reproducibility was not possible, particularly in the presence of ferrous hydroxide, which was probably oxidized to varying degrees depending upon small differences in the conditions. Nevertheless, we feel that our results demonstrate clearly that porphyrins and ferrous iron combine under conditions of physiological *p*H and temperature.

In a more complete study of this problem at least two points deserve closer examination. We found that in the presence of 'Teepol' the pyridine hæmochrome of the hæm formed from protoporphyrin had an absorption maximum at 550 mμ in place of 557 mμ. We also found difficulty in getting appreciable incorporation at 37° C. (not at 100° C.) of iron into coproporphyrin formed by the autoxidation of coproporphyrinogen, as opposed to incorporation into coproporphyrin added as such.

Goldberg *et al.*[4] have shown that protoporphyrin will serve as a substrate *in vitro* for an enzyme system forming hæm from nucleated erythrocytes. It seems unlikely that protoporphyrin could be reduced to porphyrinogen by a hydrogenase of avian erythrocytes, since even a powerful reducing agent such as dithionite will not bring about this reduction.

Two distinct stages may be observed in the chemical reduction of porphyrins and in the course of re-oxidation. The fully reduced porphyrinogen (hexahydroporphin) is colourless, but an intermediate stage exhibits a yellow colour and a urobilin-like spectrum with a broad absorption maximum in the region of 500 mμ. This may be a dihydro- or tetrahydro-porphin with a dipyrrylmethene-like structure, and it is of interest that addition of dithionite reduced this intermediate to the colourless porphyrinogen (cf. ref. 3). Such reduction might well be accomplished by a reverse reaction of the erythrocyte dehydrogenases and might constitute the mechanism whereby the porphyrinogen intermediates of hæm synthesis are normally prevented from 'escaping' as uro- or copro-porphyrin, porphyrins which can no longer be drawn back into the system of hæm formation. Indeed, it might be wondered whether in pathological conditions associated with production of excess of free porphyrins, for example, porphyria cutanea tarda[5], some derangement had not occurred in these reducing systems.

From our results, and from these considerations, taken in conjunction with the known ease of entry into the porphin macrocycle of divalent ions such as iron, copper and zinc, we suggest that, in the biological formation of hæm, iron reacts with protoporphyrin, not with protoporphyrinogen.

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Evidence for the Involvement of Ferrous Iron in the Biosynthesis of δ-Aminolævulic Acid by Chicken Erythrocyte Preparations

DURING an investigation into the mode of action of 5:6-dimethylbenzimidazole as an inhibitor of δ-aminolævulic acid synthesis in particulate preparations of chicken erythrocytes[1], a range of metal ions was examined for effect on the inhibition. The following metals were without any significant effect: cobalt, copper, nickel, magnesium, manganese, lead and ferric iron. Ferrous iron, however, consistently diminished the inhibition; a typical set of results is shown in Table 1. Addition of ferrous sulphate to freshly prepared systems not containing inhibitor produced a depression of synthesis of δ-aminolævulic acid. If, however, the preparation was aged at

Table 1. Effect of Ferrous Sulphate on the Inhibition of Synthesis of δ-Aminolævulic Acid by 5 : 6-Dimethylbenzimidazole

Incubation conducted under standard conditions (ref. 1) with fresh preparation in the presence of 30 m*M* glycine and 30 m*M* citrate

Additions	δ-Aminolævulic acid (mμ moles)	Stimulation (per cent)
None	180	−41
Ferrous sulphate (1 m*M*)	106	
5 : 6-Dimethylbenzimidazole (2·7 m*M*)	40	25
5 : 6-Dimethylbenzimidazole (2·7 m*M*) + ferrous sulphate (1 m*M*)	50	

Table 2. Effect of Ferrous Sulphate and Ascorbic Acid on Synthesis of δ-Aminolævulic Acid in Fresh and Aged Preparations

Incubations under standard conditions (ref. 1) in the presence of 30 m*M* glycine and 30 m*M* citrate

Additions	δ-Aminolævulic acid (mμ moles)			
	Fresh preparation	Aged 24 hr.	Aged 48 hr.	Aged 72 hr.
None	180	62	31	25
Ferrous sulphate (1 m*M*)	106	59	40	52
Ascorbic acid (1 m*M*)	140	61	34	37

0–4° C. for periods exceeding 24 hr., then significant stimulations were obtained. Up to periods of 72 hr., the stimulation increased in magnitude with progressive ageing. Table 2 is typical of results obtained in this way.

The implication of these findings appeared to be that ferrous iron is involved at some stage in the synthesis of δ-aminolævulic acid but that, on ageing, it is progressively oxidized to the ferric state, which has been found to be devoid of stimulatory activity. If this hypothesis be correct, addition of a suitable reducing agent to aged preparations would be expected to have the same effect as addition of ferrous salts. That this is in fact the case was verified by use of ascorbic acid. As in the case of ferrous sulphate, no stimulation was obtained with fresh preparations (see Table 2). The depression of synthesis of δ-aminolævulic acid in fresh preparations by ferrous sulphate is reminiscent of the observation that several microorganisms which synthesize porphyrins (via δ-aminolævulic acid) require small amounts of iron but that larger amounts are inhibitory (see, for example, Pappenheimer[2]). That it was not due to the sulphate anion was shown by including controls containing potassium sulphate.

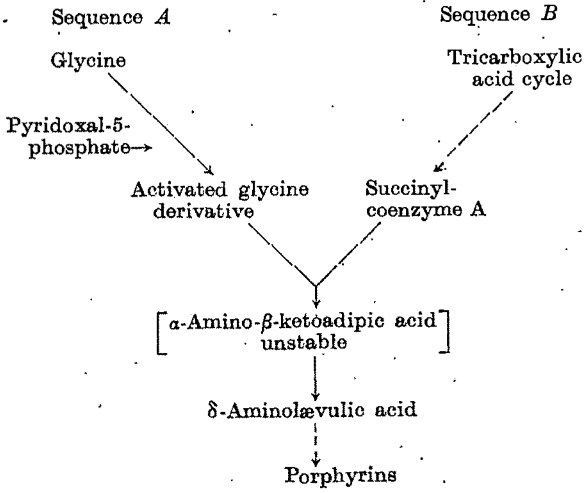
Further evidence that ferrous iron is involved was obtained by demonstrating inhibition of synthesis of δ-aminolævulic acid in the presence of α-α′-dipyridyl, a potent chelating agent for ferrous iron. This inhibition could be reversed by addition of ferric sulphate (Table 3).

Table 3. Inhibition of Synthesis of δ-Aminolævulic Acid by α-α′-Dipyridyl and its Reversal by Ferrous Sulphate

Incubations under standard conditions (ref. 1) with preparation aged for 48 hr. Substrates glycine (30 m*M*) and citrate (30 m*M*)

Additions	δ-Aminolævulic acid (mμ moles)
None	51
α-α′-Dipyridyl (1 m*M*)	41
α-α′-Dipyridyl (1 m*M*) + ferrous sulphate (1 m*M*)	50
Ferrous sulphate (1 m*M*)	80

The current conception of the early stages of porphyrin biosynthesis, of which δ-aminolævulic acid is an intermediate, may be represented as follows:



As 5 : 6-dimethylbenzimidazole inhibits somewhere[1] in sequence *A*, and in view of the relationship of this substance to stimulation by ferrous iron, it would seem likely that ferrous iron exerts its stimulatory capacity in the steps comprising sequence *A*. Preliminary experiments in which production of succinyl-coenzyme A was assayed in control aged systems and in aged systems stimulated with ferrous sulphate confirm this, ferrous iron producing no stimulation but in fact slightly inhibiting sequence *B* (see Table 4).

Table 4. Comparison of the Effects of Ferrous Sulphate on Yield of δ-Aminolævulic Acid and Production of Succinohydroxamic Acid under Comparable Conditions

Incubations conducted under standard conditions (ref. 1) with 48-hr. old preparations. Incubates for estimation of δ-aminolævulic acid contained glycine (30 m*M*) and citrate (30 m*M*). Those for estimation of hydroxamic acid by the method of Lipmann and Tuttle (ref. 7) contained 40 m*M* hydroxylamine but neither glycine nor pyridoxal-5′-phosphate

Additions	Succinohydroxamic acid (mμ moles)	δ-Aminolævulic acid (mμ moles)
None	550	54
Ferrous sulphate	410	99

By analogy with other pyridoxal-5′-phosphate systems, it seems likely that glycine is activated by the formation of Schiff's base with pyridoxal-5′-phosphate (the involvement of the latter in the formation of δ-aminolævulic acid having been demonstrated by Schulman and Richert[3]) and that a metal may be involved in stabilizing the base by chelation. This may well be the site of action of the stimulation by ferrous iron. Evidence has been presented recently by Patwardhan[4] that ferrous iron might be involved in the reaction mechanism of glutamic-oxaloacetic transaminase, another pyridoxal-5′-phosphate system.

That iron is involved in the synthesis of porphyrins has been suggested previously. Duesberg[5], for example, demonstrated decreased porphyrin excretion in patients with iron deficiency. Further, Heilmeyer and Plöttner[6] reported that intravenous injection of ferrous ascorbate leads to synthesis of hæmoglobin in excess of that calculated for complete utilization of the iron supplied. Pappenheimer[2] has shown that synthesis of porphyrin in *Corynebacterium diphtheriae* is stimulated by iron (ferrous sulphate) in concentrations up to 0·1 mgm./l. of culture medium, although concentrations in excess of this are inhibitory. Again, it has been known for many years that iron is required for the synthesis of chlorophyll in plants, although chlorophyll itself does not contain this metal. δ-Aminolævulic acid, however, is an intermediate of this biosynthetic process[8]. Further work on these observations is in progress and will be reported in full elsewhere.

I wish to thank Prof. C. Rimington for his interest and advice and Miss B. Knight for technical assistance during the course of this work, which was carried out during the tenure of an I.C.I. Research Fellowship.

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Effect of Copper Deficiency on Synthesis of Hæm

Although copper is essential for the formation of normal hæmoglobin, it has not been demonstrated that this element functions directly in the synthesis of hæm. We have demonstrated an increased synthesis of hæm *in vitro* from glycine labelled with carbon-14, by means of adding inorganic copper to copper-deficient chicken blood.

Cross-bred chicks from a commercial hatchery were rendered deficient in copper in two weeks by feeding the following diet: non-fat milk solids, 55 per cent; glucose-monohydrate, 40 per cent; cotton-seed oil, 2 per cent; glycine, 0·6 per cent; L-arginine monohydrochloride, 0·5 per cent; L-cystine, 0·2 per cent; choline chloride, 0·6 per cent; and sodium chloride, 0·5 per cent. In addition, each 100 gm. of diet contained 2 mgm. of nicotinic acid, 240 I.U. of vitamin A-palmatate, 12·4 mgm. magnesium sulphate, 1·9 mgm. manganese sulphate and the equivalent of 14 mgm. carbonyl iron (General Aniline Works, Grasselli, New Jersey). The iron was fed in the carbonyl form in experiments 1, 2 and 3 and in the chloride form in experiments 4, 5 and 6. The control diets were supplemented with 1·6 mgm. of copper sulphate per 100 gm. of diet. The criteria for deficiency in copper were reduced growth-rate and hæmoglobin concentration.

To determine the effect of a deficiency of copper on synthesis of hæm, 0·1 ml. of a solution of glycine containing 1 μc. methylene-labelled glycine and sufficient non-labelled glycine to yield a final concentration of $1·33 \times 10^{-2}$ *M* was added to either 3 or 5 ml. of heparinized whole blood. In addition, antibiotics[1] and 0·1 ml. of a ferrous sulphate solution were added to yield a final concentration of 2×10^{-4} *M*, as recommended by Dresel and Falk[2]. All samples were incubated at 37·5° C. under an oxygen atmosphere in a Warburg apparatus for 24 hr. Hæm was isolated and recrystallized according to the method of Shemin *et al.*[1], except that strontium chloride was used instead of sodium chloride. A large excess of carrier hæm was added in experiments 2, 3, 4 and 6 but not in experiments 1 and 5. In each experiment blood samples from 4–10 chicks were pooled and incubated either with or without supplemental copper sulphate to a final concentration of $1·6 \times 10^{-5}$ *M*.

Table 1. Effect of Copper on Synthesis of Hæm in Blood Deficient in Copper

Experiment*	Treatment†	Weight gain‡ (gm.)	Hb (gm. per cent)	Specific activity of hæm −Cu	Specific activity of hæm +Cu	Standard error of the mean $S_{\bar{x}}$	Significant level of the copper effect
1	Control	68·8	7·35	37·8	37·7	±3·5	0
	Cu-def.	34·5	3·70	12·1	29·0		0·01
2	Control	62 0	6·52	9·4	7·9	±0·6	0
	Cu-def.	36·4	4·25	6·7	9·3		0·05
3	Control	62·0	5·78	2·3	3·3	±0·2	0·05
	Cu-def.	36·4	4·25	1·9	2·5		0·05
4	Control	69·8	8·39	8·0	7·9	±0·6	0
	Cu-def.	39·9	5·18	8·7	11·1		0·01
5	Control	95·0	6·33	39·1	27·9	±0·8	0·01
	Cu-def.	66·0	3·57	24·9	23·7		0
6	Control	69·8	8·39	4·3	1·6	±0·4	0·01
	Cu-def.	39·9	5·18	3·8	3·6		0

* Results in experiments 1, 2 and 3 are from chicks fed carbonyl iron. Results in experiments 4, 5 and 6 are from chicks fed iron chloride.

† Control diet contained 1·6 mgm. copper sulphate per 100 gm. of diet.

‡ The weight gains in experiment 5 are for four weeks and all others are for two weeks.

The results in Table 1 show that in blood from chicks deficient in copper and fed the diet containing carbonyl iron, synthesis of hæm was reduced, but the addition of copper to this blood consistently increased this synthesis. Blood obtained from chicks deficient in copper and fed iron chloride, however, gave an increased synthesis of hæm in the presence of copper only in experiment 4. With the exception of experiment 3, the addition of copper to the blood from control chicks failed to increase the synthesis of hæm. This exception may possibly be related to the low concentration of hæmoglobin in the control chicks of this experiment.

The results obtained in these experiments demonstrate that copper has a direct function in the synthesis of hæm. From the fact that the copper effect was obtained consistently only when carbonyl iron—a source of iron of low availability—was used in the diet, it appears that a dual copper–iron deficiency may be essential to demonstrate the effect of copper on the *in vitro* synthesis of hæm.

Experiments are in progress to determine the site(s) of copper activity in the synthesis of hæm. Recently, Iodice, Richert and Schulman[3] have demonstrated that δ-aminolævulinic acid dehydrase contains copper and that its activity is reduced in copper-deficiency. It is possible, however, that copper has functions in the synthesis of hæm other than in connexion with this enzyme and the system described here should prove beneficial in elucidating the role of copper in the synthesis of hæm.

We wish to thank Dr. C. H. Hill for providing the chicks used in these experiments and for his aid and advice in the care and feeding of them. This project was partially supported by a grant from the Frasch Foundation.

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Effect of Gamma-Radiation on Ferriprotoporphyrin

In dilute aqueous solution the oxidized prosthetic group of hæmoglobin and catalase, ferriprotoporphyrin (the ferric iron derivative of 1,3,5,8-tetramethyl-2,4-divinylporphine-6,7-dipropionic acid) may be affected by ionizing radiation at several places in its complex structure. Dale and Russell[1] and Barron and Johnson[2] observed spectroscopic changes which led them to conclude that the porphyrin ring was broken. In addition, Barron and Johnson found that in the absence of oxygen the spectrum was changed to that of a ferroprotoporphyrin. We have obtained spectroscopic evidence that a new compound is produced before the ring is broken, and that the vinyl side-chains play an important part in its formation. It is also found that hydrogen peroxide will produce this compound.

Irradiation of an aerated 10^{-5} *M* solution of ferriprotoporphyrin in 0·1 *N* sodium hydroxide with 15,000 r. of γ-rays from a cobalt-60 source results in a shift of the visible absorption peak from 612 mμ to 600 mμ and in a small decrease in its intensity. The visible absorption spectra have isosbestic points at about 415, 495, 560, 605 and 640 mμ, which suggests that the reaction is one in which one coloured compound is being changed into another single-coloured compound. Above 15,000 r. a general decrease in intensity of the entire visible absorption spectrum is observed. As the visible spectrum changes during the initial period of radiation, a rapid non-exponential decrease of about 28 per cent in the Soret peak (at 385 mμ) also occurs; this is followed (above 15,000 r.) by a less rapid, exponential decrease. The rate curve based on the decreased absorption of the Soret peak is typical of two consecutive first-order reactions in which compounds *A* and *B* possess the property which is being measured, and *C* does not, and in which the rate of conversion of *A* to *B* is much faster than of *B* to *C*. These observations are in accord with an initial reaction in which a compound, *B*, with an intact porphyrin ring, is produced, followed by reactions resulting in a rupture of the porphyrin ring structure.

Further evidence that compound *B* is an iron porphyrin pigment can be found in its reaction with pyridine. The compound with the absorption band at 600 mμ and the less intense Soret peak at 385 mμ was precipitated by acidifying the alkaline solution, and the precipitate was dissolved in 25 per cent aqueous pyridine. The absorption spectrum of this solution had peaks characteristic of a pyridine ferriprotoporphyrin. When dithionite was added, the spectrum changed to one having visible band maxima at 522 and 554 mμ and a Soret peak at 417 mμ. This spectrum resembles that of pyridine ferroprotoporphyrin, which has visible band maxima at 525 and 556 mμ, and a Soret peak at 420 mμ. It was shown that the new compound was stable to treatment with pyridine by acidifying the pyridine solution, thus precipitating a pigment, the visible absorption spectrum of which in 0·1 *N* sodium hydroxide was identical with that of the 600 mμ compound. Application of this procedure to pyridine ferroprotoporphyrin itself yields ferriprotoporphyrin.

Treatment of alkaline ferriprotoporphyrin with about an equimolar amount of hydrogen peroxide results in changes in the visible and ultra-violet spectra which are difficult to distinguish from those produced by 15,000 r. of γ-radiation. A gradual change in the spectrum could be followed using fractional equivalents of hydrogen peroxide. Isosbestic points were observed at the same positions as in the radiation reaction. Much larger amounts of hydrogen peroxide did not change the position of the bands, but did cause the very slow general decrease in the intensity of the visible and Soret regions of the spectrum reported by Lemberg and Legge[3]. There seems to be little doubt that the reaction of alkaline ferriprotoporphyrin with dilute hydrogen peroxide is closely analogous to that produced by low doses of γ-radiation. Dilute potassium permanganate also reacts with alkaline ferriprotoporphyrin in a similar manner, shifting the 612 mμ peak to 600 mμ.

Evidence of the importance of the vinyl groups of ferriprotoporphyrin on the production of the new compound was obtained by comparative studies with ferrideuteroporphyrin. Irradiation of dilute alkaline solutions of ferrideuteroporphyrin (the ferric iron derivative of 1,3,5,8-tetramethylporphine-6,7-dipropionic acid) prepared by melting ferriprotoporphyrin with resorcinol to remove the side chains in the 2 and 4 positions[4], caused no shifts in the peaks of the visible absorption spectrum, and the decrease in the Soret peak approximates to that of a single first-order reaction. The rate for doses to 10^5 r. is approximately the same as that for a ferriprotoporphyrin solution of the same initial concentration from 15,000–10^5 r. These observations suggest that the initial effect of γ-irradiation on ferrideuteroporphyrin, unlike that on ferriprotoporphyrin, results in a rupture of the porphyrin ring structure. It clearly follows, then, that the vinyl side chains are necessary for the formation of the new compound from ferriprotoporphyrin. Whether they act by activating some other part of the porphyrin molecule, or whether they take part directly in the radiation reaction, or possibly both, however, remains a subject for further research.

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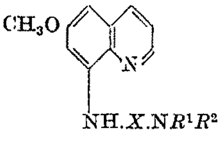
A New Series of Leishmanicides

The first synthetic antimalarial that found a place in medicine was pamaquin (plasmochin), which is an 8-aminoquinoline derivative (I; $X = CHCH_3.[CH_2]_3$; $R^1 = R^2 = C_2H_5$), and since its discovery more than twenty-five years ago[1] many examples of the class have been prepared, of which some exceed pamaquin in antimalarial activity.

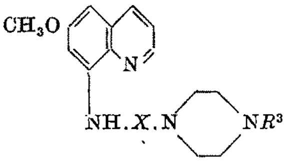
We have now found that a closely defined group of compounds of this class (patent applications pending) possess the rare attribute of chemotherapeutic activity against *Leishmania*, the protozoan parasite which causes kalar-azar and oriental sore.

The substances were tested in hamsters infected with several strains of *Leishmania donovani* by the methods described by Goodwin[2,3]. The active members of the series were more effective than quinquevalent antimonials and aromatic diamidines when given subcutaneously, and unlike the other leishmanicidal drugs, they are also active when given orally.

The essential structural criterion is that piperazino shall be the terminal basic group in place of NR^1R^2, the active class being represented by (II) in which X is a straight or branched alkylene chain.



(I)



(II)

The consequential introduction of a further basic centre is not itself the decisive feature in that compounds such as (I; $X = [CH_2]_2.NH.[CH_2]_2$) are inactive, as indeed are those with other basic terminal rings (for example, morpholino, piperidino, pyrrolidino). Compounds of this class with 5 : 6-dimethoxy and those in which the 6-methoxy- is replaced by a 6-hydroxy- or a 6-ethoxy-group are also active, but 6-chloro- and 6-unsubstituted compounds are without significant activity. A wide variation of the alkylene group X is permitted, and activity is notably high for $X = [CH_2]_3$. Activity is maintained with a variety of N-substituents of the piperazine ring, and is high for $R^3 = H$ or alkyl; compounds with hydroxyalkyl in this position are also very effective. Compounds with substituents in this position, such as CO_2Et, $CO.NEt_2$ or aryl, that suppress or greatly reduce the basic character of the terminal nitrogen atom, are usually inactive.

Some members of the series possess high activity against *Plasmodium gallinaceum* in chicks.

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The Morphinized–Eserinized Leech Muscle for the Assay of Acetylcholine

The use of the eserinized dorsal wall of the leech as an assay object for acetylcholine has proved unsatisfactory in the past because of inadequate relaxation and decreasing sensitivity in most preparations.

As Paton *et al.*[1] had shown that morphine decreased the output of acetylcholine in the electrically stimulated ileum of the guinea pig, it was decided to investigate the influence of morphine on the relaxation of the eserinized leech. Morphine was found to facilitate relaxation and in a suitable concentration (4 or 5 × 10^{-5} gm./ml.) did not appreciably decrease the sensitivity to acetylcholine. In a higher concentration (10^{-4} gm./ml. or greater) it depressed the response to acetylcholine as had been previously described by other workers[2].

The dorsal wall was cut longitudinally and horizontally to give four strips. The magnification was 20-fold and the tension equivalent to 2 gm. The composition of the oxygenated Ringer solution was as follows: sodium chloride 9, potassium chloride 0·42, calcium chloride 0·24, sodium bicarbonate 0·15 and dextrose 1 gm. in 1·4 litres of distilled water. The *p*H was 7·3.

Initially the leech strip was immersed in morphine sulphate (4 or 5 × 10^{-5} gm./ml.)–Ringer and left until adequately relaxed, usually 3 hr. or less, the lever being tapped occasionally. The strip was then immersed in morphine (4 or 5 × 10^{-5} gm./ml.)–eserine sulphate (10^{-5} gm./ml.)–Ringer for 30 min. before commencing an assay. The eserine usually caused only a slight contracture. The morphine–eserine–Ringer was used for washing throughout. As the test solutions consisted of mammalian–Ringer perfusates containing 10^{-5} gm./ml. eserine, which were diluted with distilled water (10–14 ml.) before assay, acetylcholine was applied in eserine (7 × 10^{-6} gm./ml.)–Ringer and allowed to act for 1½–3 min. The preparation was washed two or three times and relaxation was facilitated by tapping the lever. Suitable assays were carried out in twenty experiments on eighty strips. On most strips the threshold concentration of acetylcholine was 10^{-9} gm./ml. Occasionally it was 1·5 × 10^{-9} gm./ml. and in two 0·5 × 10^{-9} gm./ml. In no case did the sensitivity fall off during a 3–5 hr. assay. Smoking during an assay did not appear to interfere with relaxation. In one experiment in which the strip was immersed in Ringer containing 7 × 10^{-6} gm./ml. eserine with the morphine proportionally reduced (3 × 10^{-5} gm./ml.), the sensitivity to acetylcholine was decreased. Evidently the concentration of eserine and morphine is critical.

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A Reduced Diphosphopyridine Nucleotide Oxidase in Lettuce Seeds

Various enzymes oxidizing reduced diphosphopyridine nucleotide by pathways other than the cytochrome system have been described. Kern and Racker[1] indicated an oxidase dependent on a product of the oxidation of ascorbic acid, and Nason *et al.*[2] have shown the existence of a nucleotide–quinone reductase. Mapson and Moustafa[3] have shown the oxidation of reduced triphosphopyridine nucleotide by an enzyme linked to glutathione, while Kersten *et al.*[4] have demonstrated the existence of an oxidase dependent on ascorbic acid. Hackett[5] has shown that the ascorbic acid oxidase of potato tubers can oxidize reduced diphosphopyridine nucleotide. Dry lettuce seeds seem to contain an enzyme which does not correspond to those previously described.

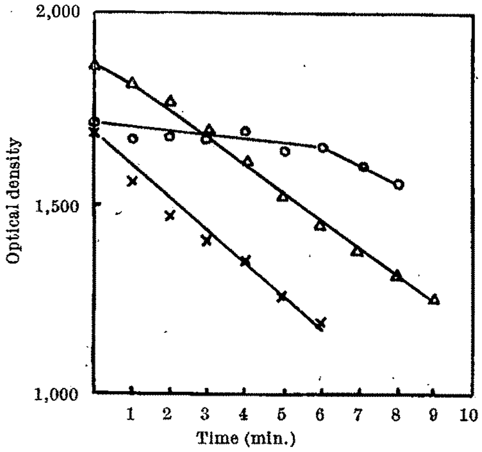

Fig. 1. The oxidation of reduced diphosphopyridine nucleotide in the presence and absence of ascorbic acid. ×, No ascorbic acid added; ○, 0·1 mgm. ascorbic acid/cuvette; △, extract pre-incubated with 0·1 mgm. ascorbic acid for 7 min. before adding reduced diphosphopyridine nucleotide. (Each cuvette contained 1·5 ml. phosphate buffer *p*H 6·3, 0·1 *M*, 0·1 ml. reduced diphosphopyridine nucleotide 0·25 per cent, 0·05 ml. extract and water to 3 ml.)

Extracts of lettuce seeds contain an enzyme which readily oxidizes reduced diphosphopyridine nucleotide without any added hydrogen acceptor. Enzyme activity was followed spectrophotometrically at 340 mμ. The enzyme was not precipitated at 20,000*g* from phosphate–sucrose buffer. The ability of the enzyme to oxidize reduced diphosphopyridine nucleotide was not increased by the addition of cytochrome *c*, reduced or oxidized glutathione, benzoquinone, dihydroxyphenylalanine or dehydrascorbic acid. However, small amounts of ascorbic acid completely inhibited the activity of the enzyme. As the ascorbic acid was destroyed by ascorbic acid oxidase present in the extracts, this inhibition was overcome, but without any increase of activity over corresponding controls (Fig. 1). Thus it appears that no intermediary of the oxidation of ascorbic acid was involved in this reaction. The active extracts also had high dihydroxyphenylalanine oxidase activity. The latter was followed spectrophotometrically at 500 mμ. Both reduced diphosphopyridine nucleotide oxidase and dihydroxyphenylalanine oxidase were inhibited by thiourea and diethyldithiocarbamate. Inhibition of the two systems was similar but not identical. This suggested that the reduced diphosphopyridine nucleotide oxidase is an enzyme containing copper. That it is not ascorbic acid oxidase is shown by its very different sensitivity to thiourea, since this is totally inhibited by $1\cdot 4 \times 10^{-4}$ *M* thiourea, while the reduced diphosphopyridine nucleotide oxidase is totally inhibited only by $1\cdot 3 \times 10^{-3}$ *M* thiourea. Moreover, ascorbic acid oxidase activity rises with increasing time of germination of the lettuce seeds[6], while reduced diphosphopyridine nucleotide oxidase activity falls in the same circumstances. Dihydroxyphenylalanine oxidase activity shows a similar fall in activity. After acetone fractionation, both reduced diphosphopyridine nucleotide oxidase activity and dihydroxyphenylalanine oxidase activity appeared in the same fraction. However, the latter decreased on fractionation, indicating either partial inactivation or some special co-factor requirement. These results suggest that the same enzyme may oxidize both reduced diphosphopyridine nucleotide and dihydroxyphenylalanine. This possibility as well as the co-factor requirement of the enzyme and its physiological importance in lettuce seeds are being investigated. It appears that the enzyme described is not identical with the soluble reduced diphosphopyridine nucleotide oxidases described by other workers[1-4]. Fuller details of this work will be reported elsewhere.

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Hypoglycæmic Effect of Monoiodoacetic Acid and Iodoacetamide in Rats

Alloxan lowers the concentration of reduced glutathione in the blood of the rat, but apparently has no effect on reduced glutathione in this animal's pancreatic tissue when the exocrine parenchyma has atrophied as a result of a duct ligation[1]. Nor does it seem to have any effect on the principal islets in certain species of fish[2]. Since alloxan, in both these cases, has a diabetogenic effect the observations seem to suggest that the diabetogenic effect of alloxan is not due to the inhibition of enzymes containing free sulphydryl groups in the β-cells of the islets of Langerhans[3].

Monoiodoacetic acid and iodoacetamide, when administered to rats, lower reduced glutathione in the blood and in pancreatic tissue atrophied as a result of duct ligation[4]. The effect exerted by these substances on blood sugar and the cells of the islets of Langerhans has been studied in rats. First, by the administration of a single dose subcutaneously (monoiodoacetic acid, 0·05 gm./kgm. body-weight, and iodoacetamide, 0·03 gm./kgm. body-weight), and secondly, by giving a daily dose of 0·005–0·01 gm./kgm. body-weight over a period of 15 days. The blood

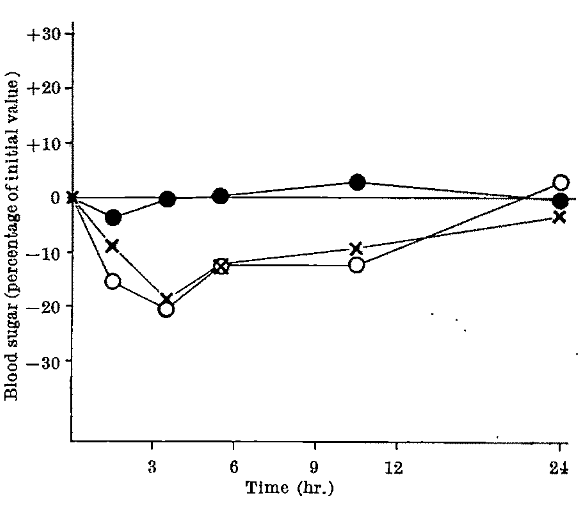

Fig. 1. Blood sugar changes, in percentage of starting value, after single administration of monoiodoacetic acid and iodoacetamide. ●——●, Control animals receiving physiological salt solution; ×——×, animals receiving monoiodoacetic acid; ○——○, animals receiving iodoacetamide

Table 1. KARYOMETRIC INVESTIGATION OF α- AND β-CELLS IN THE ISLETS OF LANGERHANS. NUCLEAR SURFACE IN μ^2. FIGURES IN BRACKETS REFER TO PROBABILITIES

	Monoiodoacetic acid α-cells	Monoiodoacetic acid β-cells	Iodoacetamide α-cells	Iodoacetamide β-cells	Control animals α-cells	Control animals β-cells
Single dose					25·5	28·8
3 hr. after injection	25·4	29·9	26·7	31·0 (0·05–0·01)		
6 ,, ,, ,,	28·4 (0·05–0·01)	32·3 (0·01–0·001)	28·6 (0·05–0·01)	31·7 (0·05–0·01)		
12 ,, ,, ,,	26·4	31·2 (0·01)	25·8	32·5 (0·001)		
24 ,, ,, ,,	25·3	31·9 (0·01)	26·0	31·8 (0·001)		
48 ,, ,, ,,	25·0	27·3	26·1	28·2		
Daily doses 15 days	25·7	27·7	24·1	27·9	26·9	27·5

sugar was determined by Hagedorn and Jensen's method, and the pancreas was stained with chromhæmatoxylin–Ponceau–fuchsin after fixation in Bouin's fluid. The nuclear size of the α- and β-cells was determined with a planimeter after the cells had been sketched at a magnification of approximately 1,700.

After the single dose of monoiodoacetic acid and iodoacetamide (Fig. 1) the blood sugar decreased, reaching its lowest value 3–4 hr. after the injection and returning to its original concentration within 24 hr. of the injection. A certain increase in the values noted a few days after the injection of monoiodoacetic acid could not be statistically demonstrated. After the administration of iodoacetamide the blood sugar values 2–3 days after the injection were lower than those for the control animals, but not lower than the starting value. No permanent increase in blood sugar was observed. When the substances were administered daily, neither hyperglycæmia nor glycosuria developed.

Microscopic examination of the pancreas at varying intervals after the injection did not reveal any necrosis in either of the cell forms in the islets; nor was any pyknosis observed in the nuclei of the islet cells. Great variability in the stainability and granulation, such as is seen in connexion with heightened function, was observed in both α- and β-cells during the 24 hr. immediately following the injection. The result of the karyometric examination can be seen in Table 1. Both forms of islet cells displayed nuclear enlargement, suggesting that increased activity was in progress. This activity persisted, in the β-cells, almost throughout the first 24 hr. after the injection, whereas in the α-cells the disturbance was of short duration. No change in nuclear size could be demonstrated after 24 hr. or after 15 days of continuous administration.

These studies have not revealed anything to indicate that monoiodoacetic acid and iodoacetamide are diabetogenic in the doses used, despite the fact that, in certain respects, they exert a stronger effect on sulphydryl substances than alloxan. The reason for the decrease in blood sugar observed after the injection of monoiodoacetic acid and iodoacetamide seems to lie in the increased β-cell activity which, to judge from the karyometric findings, arises after injection of the single dose. Nothing definite was observed to indicate damage to the α-cells.

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Species Difference in regard to the Biosynthesis of Ascorbic Acid

IN previous reports[1] [2] from this laboratory, it has been shown that the liver tissue of mammals such as the cow, goat and rat (but not the guinea pig) could produce strikingly large amounts of ascorbic acid *in vitro* with D-glucuronolactone as substrate in presence of cyanide. This did not occur in the absence of cyanide, and no other substrate except L-gulonolactone was effective. It was, however, found[1,2] that the liver tissue of birds such as the chicken and the pigeon, which are known to synthesize their own requirements of ascorbic acid, failed to synthesize ascorbic acid under these conditions. Grollman and Lehninger[3] have meanwhile shown by their method that, as opposed to mammals, the capacity for synthesizing ascorbic acid in the birds and reptiles they studied, namely, the chicken, pigeon and tortoise, resides in the kidney tissues.

It was of interest to study, by our technique using cyanide, the capacity of different species of animals, including amphibians, reptiles, birds and mammals, to synthesize ascorbic acid. Table 1 shows the results obtained.

Table 1. NET SYNTHESIS OF ASCORBIC ACID (μGM.) BY THE KIDNEY AND LIVER TISSUE HOMOGENATES

The test system contains 0·07 *M* phosphate buffer (*p*H 7·4), 0·025 *M* substrate, tissue homogenate (250 mgm.), 0·05 *M* potassium cyanide in a total volume of 5·0 ml. incubated for 2 hr. at 37·5° C.

Animal	Species	Kidney	Liver
Amphibians :			
Common Indian toad (in summer)	*Bufomelanostictus schneider*	370	0
(in winter)	,,	235	0
Reptiles :			
Bloodsucker	*Calotes versicolor* Daudin	185	0
Common Indian monitor	*Varanus monitor* (Linn.)	184	0
Birds :			
Common pochard	*Aythya ferina* (Linn.)	188	0
Chicken	*Gallus gallus*	263	0
Grey partridge	*Francolinus pondicerianus* (Gamelin)	218	0
Coot	*Fulica atra* (Linn.)	241	0
Pigeon	*Columba livia* (Gamelin)	330	0
Owl	*Otus bakkamoena pennant*	250	0
Kingfisher	*Halcyon smyrnensis* (Linn.)	72	0
House crow*	*Corvus splendens splendens* (Vieillot)	32	128
Common myna*	*Acridotheres tristis* (Linn.)	15	64
Munia*	*Lonchura malacca* (Linn.)	0	93
Bank myna*	*Acridotheres ginginianus* (Latham)	0	86
Hill myna*	*Gracula religiosa* (Linn.)	0	73
Magpie robin*	*Copsychus saularis* (Linn.)	0	56
Tree-pie*	*Crypsirina vagabunda* (Latham)	0	38
Red-vented bulbul*	*Pycnonotus cafer* (Linn.)	0	0
Mammals :			
Indian fruit bat	*Pteropus medius*	0	0
Rat		0	90

* Passeriformes.

It will be seen from Table 1 that both amphibian and reptile kidney tissues, but not their liver tissues, could synthesize ascorbic acid. The lower value of ascorbic acid obtained with the toad tissue in winter compared with summer is apparently due to its lower metabolism during hibernation in winter. In the cases of the different avian species, in those which are supposed to belong to older natural orders in the evolutionary scale[4,5], namely, the chicken, pigeon, etc., the kidney tissue and not liver could synthesize ascorbic acid. However, in the majority of the species studied belonging to the Passeriformes, a more recent natural order, the liver tissue and not the kidney tissue could synthesize ascorbic acid. In two species belonging to this natural order, namely, the house crow and the common myna, both the liver and kidney tissues could effect this synthesis, the liver being more active than the kidney. But in one species —the red-vented bulbul—belonging to this natural order, neither the liver nor the kidney could bring about the synthesis. It would thus appear that in the natural orders in the earlier stages of evolution, namely, the amphibians and the reptiles, the biosynthetic mechanism for ascorbic acid resides in the kidney tissue. It continues to be so in the different species of birds until in the most recent natural order, the Passeriformes, the liver takes over this function, a few species sharing it with the kidney in a smaller degree and one having both liver and kidney tissues incapable of effecting this synthesis. Thus in the evolutionary ascent this mechanism seems to pass from the kidney to the liver and then to disappear also from the liver.

This is in agreement with the observation that the liver tissues of all lower mammals studied except the guinea pig can synthesize ascorbic acid, but this capacity of the liver is absent in the more evolved primates. Thus in the case of the rat the liver but not the kidney can synthesize ascorbic acid. The case of the flying mammal, the Indian fruit bat, is interesting. We had expected its liver tissue, in common with that of most mammals, to be able to synthesize ascorbic acid, but neither its liver nor its kidney could do so. The bat is supposed to be closely related to the primates, which are known to be unable to synthesize ascorbic acid, and this may be further biochemical evidence for the relationship. These results indicate that although practically all species except the primates and the guinea pig are supposed to be able to synthesize ascorbic acid, it is possible that several of them cannot do so, and the cyanide technique might provide a simple means for determining this capacity.

It may be mentioned that in all these cases, the biosynthesis of ascorbic acid has been found to be inhibited by *p*-chloromercuribenzoate, this effect being reversed by reduced glutathione. This had already been observed with the liver tissue of the rat and goat[2]. It suggests that thiol groups are involved in the enzyme systems concerned, whether they are in the liver or in the kidney tissue. The fact that the enzyme systems of the liver and of the kidney of all species studied operate in the same way with respect to the effect of cyanide, specificity of substrate, effect of *p*-chloromercuribenzoate, etc., indicates that the enzyme systems concerned are identical or closely similar, whatever the species.

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Hæmoglobin and Potassium Blood Types in Some Non-British Breeds of Sheep and in Certain Rare British Breeds

Sheep may be classified into three types, *A*, *B* or *AB*, according to whether they possess one, or another, or a mixture of two distinct hæmoglobins[1-3]. They may also be classified quite independently into two types, *HK* and *LK*, according to whether the concentration of potassium in their whole blood is relatively high or low[4]. Both sets of characters are determined genetically and the genes responsible are at different chromosomal loci[3,5].

In an extensive survey of more than thirty different British breeds of sheep we have been able to show that the majority of these breeds are polymorphic with respect to the genes at both these loci, but that large differences in gene frequency occur from breed to breed[6]. The mountain and hill breeds, particularly those from the northern part of Britain, tend to have rather high frequencies of hæmoglobin *A* and *HK*, while the lowland breeds tend to have high frequencies of hæmoglobin *B* and *LK*. A detailed map of the distribution of these characters in breeds of sheep from other countries would be of obvious help in attempting to assess the biological significance of this kind of polymorphism.

During the past three years we have had the opportunity of examining the hæmoglobin and blood potassium types in a number of breeds of sheep located in widely scattered parts of the world. The data are in many respects incomplete and fragmentary, and the number of animals tested is relatively few. Nevertheless, it seems worth while recording the results at this stage because they do give a rough indication of the frequencies of these characters in sheep from very diverse places, and they may be useful to workers in other countries examining these characters in their local breeds.

Heparinized blood samples were sent by air to England from the various points of collection, and the time taken in transit varied from about three days for the Awasi (Israel) to about twenty-one days for the Merino samples from the Northern Territory of Australia. A proportion of the samples could not be used for hæmoglobin typing because of gross hæmolysis, and occasionally clotting had occurred and this prevented a satisfactory determination of the potassium content of the whole blood. We have, however, no reason to believe that one or another of the blood types were selectively affected in this way.

Table 1. HÆMOGLOBIN AND POTASSIUM BLOOD TYPES IN FOURTEEN NON-BRITISH BREEDS OF SHEEP

Breed	Sample obtained from	Believed place of origin of breed (cf. ref. 11)	Hæmoglobin types					Blood potassium types		
			No. tested	*A*	*AB*	*B*	Estimated frequency of *A* gene	No. tested	*LK*	Frequency of *LK* type
Scandinavian:										
Finnish	Finland	Finland	26	26	0	0	1·0	42	15	0·36
Icelandic	Iceland	Iceland	44	29	14	1	0·82	44	2	0·05
Old Norwegian	Norway	Norway	9	9	0	0	1·0	44	5	0·11
African/Middle East:										
Awasi	Israel	Syria, Israel and Iraq	39	0	0	39	0·0	59	15	0·25
Awasi	Iraq		47	1	3	43	0·05	48	4	0·08
Barki	Egypt	North-West Egypt	37	1	7	29	0·12	42	34	0·81
Blackheaded Persian	Tanganyika	South Africa	21	0	0	21	0·0	46	5	0·11
Fulani	Nigeria	Senegal to Cameroons	60	2	3	55	0·06	69	16	0·23
Masai	Tanganyika	Tanganyika, Kenya, Uganda	30	0	0	30	0·0	42	8	0·19
Rahmani	Egypt	Lower Egypt	43	0	1	42	0·01	43	7	0·16
Merino:										
Northern Territory, Australia	Australia	Spain	37	3	22	12	0·38	39	39	1·00
Rambouillet	France		19	11	8	0	0·79	23	23	1·00
Tasmania	Australia		24	7	14	3	0·58	25	23	0·92
Others:										
Bighorn	Canada (Alberta)	Rocky Mountains (North America)	4	0	0	4	0·0	4	0	0·00

The results are given in Table 1. The distribution of the hæmoglobin types in the Scandinavian breeds contrasts strikingly with that found in the Middle Eastern and African breeds. In the former, hæmoglobin *A* is very common, while in the latter, hæmoglobin *B* preponderates. On the other hand, *LK* is relatively infrequent both in Scandinavia and in the Middle East and Africa (with the single exception of the Barki), and it is clear that the correlation in gene frequencies between *B* and *LK* which occurs in British breeds does not apply here.

The Merinos form a distinctive and peculiar group. The three flocks studied were almost entirely *LK*, a fact which agrees with earlier reports[7,8], but both types of hæmoglobin are fairly common.

The interpretation of the results for *HK* requires special comment. It is thought probable that four types of sheep may occur, with distinctive concentrations of potassium and sodium in the red cells. These have been called[9] $Ke\alpha$, $Ke\beta$, $Ke\gamma$ and $Ke\Delta$. On whole-blood analysis $Ke\beta$, γ and Δ fall into the *HK* group and $Ke\alpha$ into the *LK* group. The distinction between $Ke\beta$, γ and Δ requires determinations of the concentrations of potassium and sodium in the red blood cells using fresh blood. In practice, whole-blood determinations are adequate in most surveys of British breeds of sheep because it has been found that $Ke\beta$ and $Ke\Delta$ are extremely rare in Britain and, therefore, *HK* almost invariably implies $Ke\gamma$. In the Middle East and Africa this is probably not the case, and it is possible that $Ke\beta$ and $Ke\Delta$ may be quite common. In Kerr's data[10] from Lebanese fat-tailed sheep, for example, $Ke\Delta$ was the most common type although all four types were demonstrated. In the present survey the potassium content of the whole blood in the *HK* group was on the average appreciably lower in the Middle Eastern and African breeds than in the Scandinavian breeds and one possible explanation of this is that $Ke\beta$ and Δ types may have been present in the former but not in the latter. Such differences can, however, only be ascertained by detailed studies using fresh blood samples.

Table 2. HÆMOGLOBIN AND POTASSIUM TYPES IN BREEDS OF SHEEP IN THE ZOOLOGICAL GARDENS, LONDON

Breed	Believed place of origin of breed	No. tested	Hæmoglobin types			Potassium types	
			A	*AB*	*B*	*HK*	*LK*
Mouflon	Corsica and Sardinia	4	2	2	0	2	2
Barbary	Libya, Tunisia and E. Algeria	5	0	0	5	2	3
Jacob's (Spanish Piebald)	? Spain ? Hebrides	7	0	6	1	0	7
Manx	Isle of Man	4	0	0	4	4	0
Soay	Hebrides	12	1	0	11	11	1
Old Norfolk Horn	England	7	0	0	7	7	0

It is appropriate also to report here the results we have obtained from testing a small number of sheep at present in the Zoological Gardens, London (Table 2). They include certain rather rare breeds. In fact, the seven examples of the Old Norfolk Horn are probably the only remaining members of this once quite numerous breed. It is notable that in spite of the small numbers involved, four out of the six breeds examined were polymorphic with respect to one or other of the two sets of characters. A further point of interest is that in the Barbary sheep it was possible to carry out determinations of the potassium and sodium in the red blood cells, and the two *HK* animals were found to be $Ke\beta$.

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Hæmoglobin *P* (the 'Galveston' Type)

An earlier communication[1] described a new variant of human hæmoglobin tentatively called the 'Galveston type'. This variant appears identical with hæmoglobin L[2] in paper electrophoresis, veronal buffer, *p*H 8·6, 0·05 *M*, but differs from similar types in that it does not separate from hæmoglobin *A* in free electrophoresis, cacodylate buffer, *p*H 6·2–6·9, 0·1 *M*. It is now suggested that this variant (found in a Negro woman, 'MTu', and in one of her two children) be called hæmoglobin *P*. Fig. 1 shows a photograph of the paper electrophoresis pattern of 'MTu's' hæmoglobin sample, compared with those from subjects with sickle cell trait, hæmoglobin *G* trait, and hæmoglobin *Q* trait. (The sample of hæmoglobin *G* trait[3] is from the subject 'AK'; that of hæmoglobin *Q* trait[4] was kindly supplied by Dr. H. Lehmann.) The various types of hæmoglobin in these samples, listed in order of decreasing mobility, are as follows: *A*, *Q*, *G*, *P* and *S*.

In other types of zone electrophoresis (starch block and agar, both in veronal buffer) 'MTu's' hæmoglobin sample is again resolved into two components, similar to those on paper. Quantitative estimation of these was obtained from the starch-block electrophoresis by determining the concentration of the eluted components spectrophotometrically; the proportions were found to be approximately 1 : 1. However, in the recently developed citrate agar method[5], 'MTu's' hæmoglobin sample was again indistinguishable from hæmoglobin *A*.

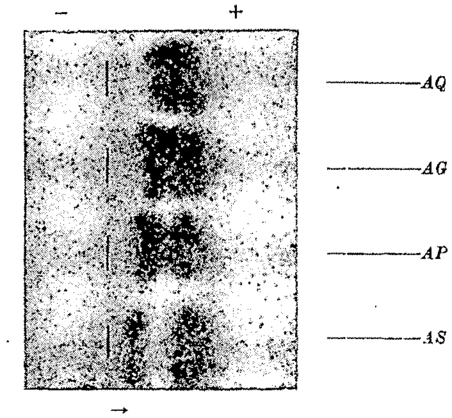

Fig. 1. Paper electrophoresis patterns of hæmoglobin samples *AQ*, *AG*, *AP* and *AS*. Veronal buffer, *p*H 8·6, 0·05 *M*

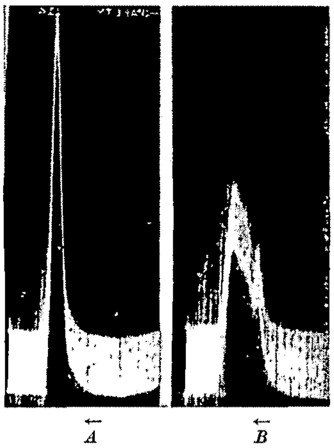

Fig. 2. Scanning diagrams of ascending patterns of 1:1 mixtures of 1 per cent carboxyhæmoglobin samples, cacodylate buffer, *p*H 6·5, 0·1 *M*. *A*, 'MTu's' (*AP*) with hæmoglobin *A*; *B*, 'MTu's' (*AP*) with 'AK's' (*AG*)

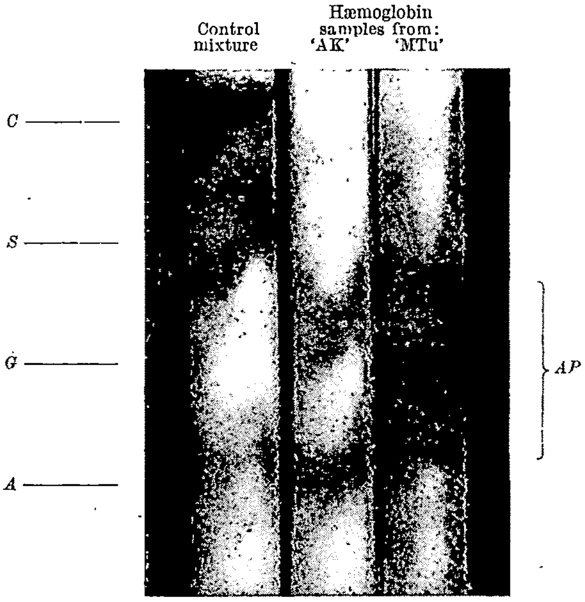

Fig. 3. Chromatography of carboxyhæmoglobin *AP* on columns of 'Amberlite' resin

It has already been noted that in free electrophoresis, cacodylate buffer, *p*H 6·5, μ 0·1, hæmoglobin *AP* migrates as one sharp peak. This was also the case in an analysis with this same buffer of a 1 : 1 mixture of 'MTu's' hæmoglobin sample and hæmoglobin *A* (Fig. 2*A*). Similarly, in free electrophoresis in phosphate buffer, *p*H 6·4, 0·04 *M*[6], the hæmoglobin *AP* of 'MTu's' sample migrates as one sharp peak. The similarity of results with these two different buffers would seem to indicate that in this *p*H range the net charge of hæmoglobin *P* is identical with that of hæmoglobin *A*. However, a lack of true identity is suggested by the fact that in free electrophoresis in cacodylate buffer, mixtures of 'MTu's' hæmoglobin sample with those containing hæmoglobin *S* or *G* develop into two peaks of variable and unpredictable proportions[1], unlike mixtures of *A* and *S* or *G*, which are resolved quantitatively; even more striking is the fact that mixtures of 'MTu's' sample with those containing hæmoglobin *AG* (from patient 'AK') were, on several occasions, resolved into a pattern suggesting the presence of three components (Fig. 2*B*).

Another method of comparing the net charge of various types of hæmoglobin in an acid buffer[7] is that of chromatography on columns of 'Amberlite' resin[8]. In this method hæmoglobin *P* is not sharply differentiated from hæmoglobin *A*, but the diffuse band produced by *AP* in comparison with that produced by *A* suggests again that these two types are not quite identical with respect to net charge in acid buffer (Fig. 3).

In free electrophoresis in an alkaline buffer (veronal, *p*H 8·6, 0·1 *M*), no clear separation was obtained between the *A* and the *P* of 'MTu's' hæmoglobin sample, but the asymmetry of the peak strongly suggested electrophoretic heterogeneity[1]. (In these circumstances the peak produced by *AG* appears relatively symmetrical[9]. This suggests that in free electrophoresis, veronal buffer, as in zone electrophoresis, the mobility of *P* is slightly less than that of *G*.) In an attempt to sharpen this heterogeneity, an aliquot of hæmoglobin *A* was added to an equal amount of 'MTu's' hæmoglobin sample, and the mixture was analysed in free electrophoresis, veronal buffer, *p*H 8·6, 0·1 *M*. It was then resolved into two distinct peaks in both the ascending and descending patterns, and the areas of these peaks were in about the expected proportions (3*A* : 1*P*).

Hæmoglobin *P* may now be characterized as follows: in zone electrophoresis, veronal buffer, *p*H 8·6, the mobility of *P* lies between *G* and *S*, like that of hæmoglobin *L*[2]. In free electrophoresis in acid buffer (cacodylate *p*H 6·2–6·9, 0·1 *M* or phosphate, *p*H 6·4, 0·04 *M*) the mobility of *P* appears identical with that of *A*. However, in analyses of mixtures of *P*, *A* and *G* (cacodylate *p*H 6·5), there is indication that in this *p*H range the net charge of *P* is not precisely the same as that of *A*, but rather that *P* overlaps *A* and *G* in this respect. This is also suggested by the results of column chromatography with 'Amberlite', citrate buffer, *p*H 6·5 (ref. 8). In free electrophoresis in alkaline buffer (veronal, *p*H 8·6, 0·1 *M*) *P* does not separate clearly from *A* in a 1 : 1 mixture of these two types. However, in a mixture containing approximately three parts of *A* and one part of *P*, quantitative separation does occur, and the mobility of *P* (as in zone electrophoresis) is less than that of *A*. Finally, in free electrophoresis at *p*H 6·5 of mixtures of *P* with other types of hæmoglobin, the qualitative and quantitative resolutions of *P* are to a unique extent influenced by the nature of the companion proteins.

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Gamma-Amino-*n*-Butyric Acid and Spinal Synaptic Transmission

A MAJOR constituent of factor I isolated from mammalian brain has been shown to be γ-amino-*n*-butyric acid[1]. It has been assumed that this material, an inhibitor of the crayfish stretch receptor, is an inhibitory transmitter substance within the mammalian central nervous system[2]. Recent investigations indeed have shown that γ-amino-*n*-butyric acid reversibly depresses the potentials arising from the synaptic activation of cells within the cerebral cortex[3] but no precise differentiation as to the mode of action of γ-amino-*n*-butyric acid has been attempted.

In the present investigation, γ-amino-*n*-butyric acid has been passed electrophoretically, as a cation, from one barrel of a multi-barrelled electrode. The responses, both of single cells and of groups of cells within the spinal cord of the cat, have been recorded from another barrel of the electrode filled with 4 *M* sodium chloride solution.

In the dorsal horn and intermediate nucleus of the spinal cord, cells caused to discharge by volleys in skin or muscle afferent fibres are prevented from firing by γ-amino-*n*-butyric acid. Similarly in the ventral horn, motoneurones cannot be fired either orthodromically or antidromically under the influence of γ-amino-*n*-butyric acid. In addition, the antidromic responses of small motoneurones, and the responses of Renshaw cells both to synaptic stimulation and activation by ionophoretically applied acetylcholine, are prevented by γ-amino-*n*-butyric acid. All these effects of the acid are evoked by currents of 20–350 × 10^{-9} amp. and are of short latency and rapidly reversible.

In both the dorsal and ventral horns focal synaptic potentials, recorded extracellularly and evoked by simultaneous excitation or inhibition of groups of cells, are diminished or even abolished by γ-amino-*n*-butyric acid. This reduction of excitatory focal synaptic potentials is not altered by strychnine administered intravenously, and is not accompanied by any diminution in the size of potentials recorded simultaneously from the pre-synaptic fibres. Excitatory synaptic potentials, evoked in motoneurones by impulses in group *Ia* afferent fibres, and recorded extracellularly as negative potentials, could be converted into positive potentials, indicating that the membrane behaving as a sink for current had been converted into a source.

These results make it extremely unlikely that γ-amino-*n*-butyric acid is a transmitter substance in the mammalian spinal cord. In particular, the abolition of the excitatory post-synaptic potentials of motoneurones recorded extracellularly excludes the possibility that γ-amino-*n*-butyric acid is the inhibitory transmitter upon these cells. Although it might be expected that excess inhibitory transmitter would lead to hyperpolarization of the cell with abolition of inhibitory post-synaptic potentials, the actual alteration in the membrane conductance would be small[4]. Hence, post-synaptic excitatory potentials would not be abolished and focal synaptic potentials, consisting predominantly of extracellularly recorded excitatory potentials, would still be recorded.

Accordingly, it is probable that γ-amino-*n*-butyric acid has a depressant action on the whole somadendritic membrane of centrally located neurones, both the chemically activated subsynaptic membrane and the remaining electrically activated post-synaptic membrane.

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Self-depression of the Subcutaneous Absorption of Drugs due to Release of Histamine

In experiments on the subcutaneous absorption of drugs from injected solutions we have demonstrated a marked self-depression of the subcutaneous absorption, due to histamine released by the injection trauma.

The absorption experiments were carried out by injecting 2 ml./kgm. of an aqueous sulphacetamide sodium solution (50 mgm./ml.) subcutaneously to rabbits and rats, and then determining the concentration of sulphacetamide in the serum at different times after the injection[1,2]. Both in rabbits (Fig. 1) and in rats (Table 1) the concentrations in serum, compared with control experiments, were markedly lowered for the first 20 min. after the injection, when histamine hydrochloride (90 μgm./ml.) was added to the injection fluid. Histamine dilates capillaries and enhances their permeability. Therefore, delayed absorption is possibly due to the preponderance of the transcapillary filtration during the formation of the œdema provoked by histamine.

Table 1. CONCENTRATION OF SULPHACETAMIDE IN SERUM (μGM./ML.) FROM RATS, 5 MIN. AFTER SUBCUTANEOUS INJECTION OF 2 ML./KGM. OF A SULPHACETAMIDE SODIUM SOLUTION (50 MGM./ML.)

Pre-treatment	No. of experiments	Mean	Standard error of mean	*P*
Controls	16	53·6	± 2·5	
Histamine locally	9	38·3	± 4·5	< 0·001
Histamine depleted	10	71·4	± 3·1	< 0·001
Mepyramine	8	77·7	± 2·5	< 0·001

In experiments on rats, where the concentration of sulphacetamide was determined in serum 5 min. after the subcutaneous injections, depletion of the tissue histamine content and blocking the sensitivity to histamine by mepyramine maleate gave a pronounced and statistically significant rise in the concentrations measured, when compared with the results from experiments on untreated animals (Table 1). The difference amounted to about 30 per cent. The histamine depletion was brought about with compound 48/80, giving 0·25, 0·50, 0, 1·0, 1·0, 0, 1·5, 2·0 and 2·5 mgm./kgm. intraperitoneally in a 1/2,000 solution in saline (8·5 mgm./ml.) on the first to the tenth day. Absorption experiments were performed on the eleventh day. 50 mgm./kgm. mepyramine maleate (25 mgm./ml. in saline, 8·5 mgm./ml.) was given in a single dose intraperitoneally 45 min. before the absorption experiments.

The results mentioned above have been confirmed in absorption experiments on rats with subcutaneous injection of 5 ml./kgm. morphine hydrochloride (20 mgm./ml.) solution, in collaboration with Kirsten Milthers, using a method for the determination of small quantities of morphine in blood, developed by Milthers[3]. Morphine is known to be a chemical histamine liberator. Therefore a marked self-depression of the subcutaneous absorption of morphine was expected. This view was confirmed by the experimental results. The concentration of morphine in the blood 10 min. after a subcutaneous injection is 100 per cent higher in rats depleted of histamine or treated with mepyramine (7·5–10 μgm./ml.) than in untreated control animals (about 4 μgm./ml.).

From the experimental results, I suggest that the subcutaneous absorption of drugs is normally reduced for the first 20 min. after the subcutaneous injection due to a self-depression caused by release of tissue (mast-cell) histamine. When the injected drug is a chemical histamine liberator, such as morphine, the self-depression is very pronounced. When the injected drug is without chemical histamine-releasing activity, only the injection trauma and the injection of a non-physiological fluid (which a drug solution is) provoke a lesser liberation of histamine, giving a smaller, but qualitatively similar, self-depression of the absorption-rate.

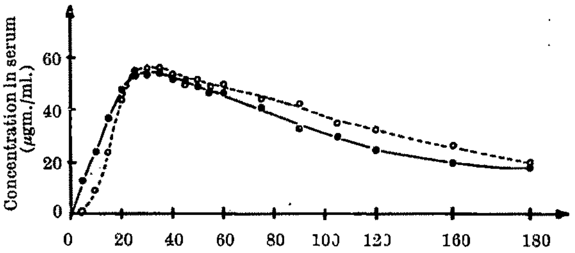

Fig. 1. Mean curves showing the concentration in serum (μgm./ml.) from three cross-over absorption experiments on rabbits given 2 ml./kgm. sulphacetamide sodium (50 mgm./ml.) subcutaneously on the abdomen. ●——●, Controls; ○– – –○, experiments with histamine hydrochloride (90 μgm./ml.) added to the injection solution

I am grateful to Prof. Knud O. Møller, for his interest in this work, and to Dr. A. C. Withe, of the Wellcome Research Laboratories, for a sample of compound 48/80.

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Level of Liver Glycogen in Ketosis

SINCE von Mering and Minkowski[1] showed that the liver of the depancreatized dog contains little glycogen, it has been widely held that the degree of ketosis is inversely proportional to the level of liver glycogen. Thus Mirsky[2] believes that ketogenesis in diabetes mellitus arises either as a result of glycogenolysis or when the liver glycogen has fallen to a critical level. Burn and Ling[3] have shown that the same relationship holds for the normal rat on a high fat diet. However, evidence is accumulating which shows that this inverse relation is by no means invariable. Appreciable quantities of hepatic glycogen have been found in severely diabetic subjects[4], and in ketotic rats after alloxan administration[5]. It has been shown in this laboratory that in the intact normal rat it is possible to obtain a very high ketonæmia concomitant with high levels of liver glycogen.

Female rats were fasted for 24 hr. to reduce the liver glycogen to minimal levels and then placed on a diet of filtered butter fat (plus 3 per cent salts). 7 gm. of the diet were fed to each rat daily, the portion not consumed voluntarily being administered by stomach tube. The course of the ensuing ketonæmia and ketonuria (Fig. 1) was followed by the method of Mayes and Robson[6]. After 7 days the rats were killed by cervical fracture and the left lateral lobe of the liver assayed for glycogen. Fat was estimated in the remainder of the liver by extraction with ether. Since the glycogen- and fat-levels of the

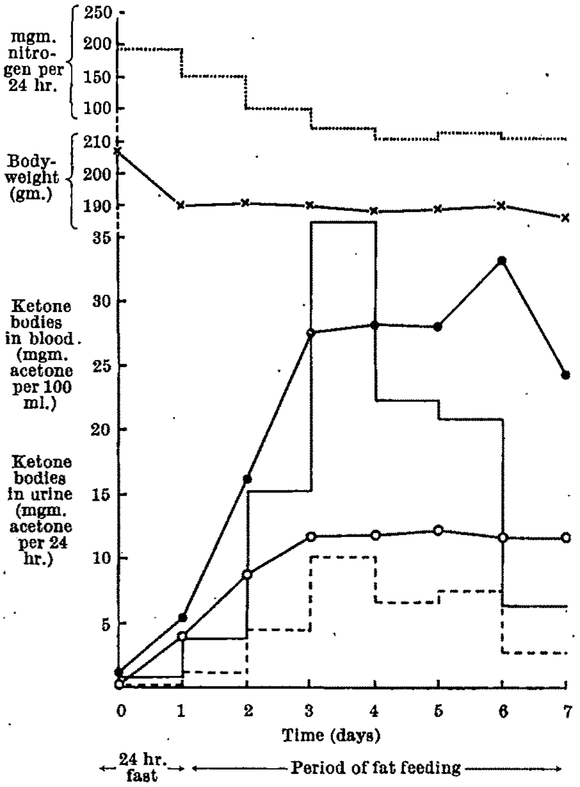

Fig. 1. The course of ketosis in rats (mean of three) starved for 24 hr., then fed 7 gm. per day of butter fat. ●, β-Hydroxybutyric acid in blood; ○, acetone plus acetoacetic acid in blood; ——, β-hydroxybutyric acid in urine; — — —, acetone plus acetoacetic acid in urine; ×, body-weight; ····, total nitrogen in urine

liver fluctuate widely under varying conditions, they are expressed in terms of the glycogen-free, fat-free dry liver weight. The experiments were carried out during the month of May.

Fig. 1 shows that the ketonæmia rose rapidly and after the third day remained at a high level. The ketonuria reached a maximum and thereafter subsided considerably. Seemingly, the apparent renal threshold for ketone bodies changed during the course of the experiment. The individual values at death for liver glycogen and fat are shown in comparison, with the corresponding ketonæmic levels (Table 1). Normal or appreciable quantities of liver glycogen were found to co-exist with a high ketonæmia. Moreover, the liver fat was substantially elevated, thereby demonstrating the lack of any mutual exclusion effect with glycogen. Increased gluconeogenesis from protein was not responsible for the accumulation of glycogen in the liver, as the levels of total urinary nitrogen remained depressed.

Table 1. LEVELS OF KETONÆMIA, LIVER GLYCOGEN AND LIVER FAT IN RATS STARVED FOR 24 HR. THEN FED 7 GM. PER DAY OF BUTTER FAT FOR SIX DAYS

	Total ketone bodies in blood (mgm. acetone/100 ml.)	Liver glycogen		Liver fat	
		Total (mgm.)	gm./100 gm. of glycogen and fat-free dry weight	Total (mgm.)	gm./100 gm. of glycogen and fat-free dry weight
Rat 1	16·44	279	23·1	1,200	99·2
Rat 2	40·82	139	10·8	885	68·6
Rat 3	50·00	190	14·7	1,023	79·0
Normal fed controls (3)	1·63*	335	21·4	146	9·42

* Mean initial level of experimental rats fed butter fat.

The general and undisputed occurrence of ketosis when the liver glycogen-level is low provides the best evidence for an inverse relation. The finding of ketosis in the presence of high concentrations of liver glycogen need not necessarily invalidate this concept. The present results may be interpreted as indicating that in the normal animal a non-glycogenolytic ketogenic factor (or factors) is able to operate, the effect of which is superimposed on the inverse relation between the level of liver glycogen and the degree of ketosis. It is noteworthy that Houssay[7], and others, have described hormonal preparations of the anterior pituitary gland which possess these properties. Such a mechanism could account adequately for the variations in severity of ketosis in diabetic and non-diabetic animals which cannot be explained by the level of liver glycogen alone.

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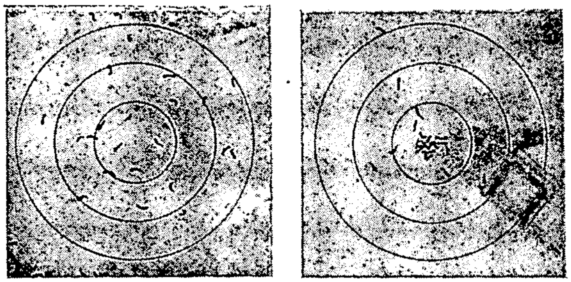
Substances in Mulberry Leaves which attract Silkworm Larvæ (*Bombyx mori*)

ALTHOUGH the larvæ of silkworms eat a few kinds of leaves other than mulberry leaves, for example, fig and lettuce, these do not support normal growth. Proteins and carbohydrates are necessary food substances, but are incapable of acting as attractants, since they are odourless. Experiments showed that mulberry leaves placed within 3–4 cm. of silkworm larvæ did attract them. An investigation was carried out on thirty-eight species of leaves as to the chemotaxis of silkworm larvæ[1]. It was found that substances which attract silkworm larvæ exist widely in green plants, but that the degree of attractivity differs. The leaves of soya bean, mulberry and tea had the strongest attractivity, but the silkworm larvæ gathered around them without eating them. On the other hand, silkworms exhibited a weak chemotaxis to the leaves of fig and lettuce, but ate them when hungry.

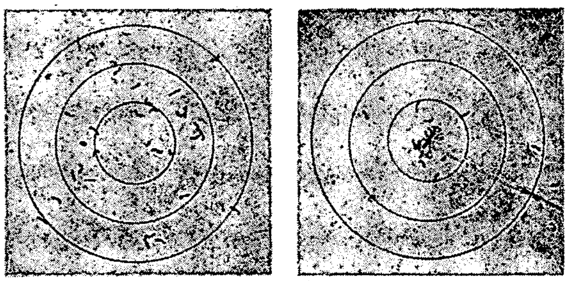
Commercially available organic acids, aldehydes, alcohols and ketones, which are present in green plants, were investigated as to the chemotaxis of silkworm larvæ, but had little effect[1]. *iso*Valeraldehyde, which is known to attract flies[2], hexyl alcohol and *iso*amyl alcohol were slightly positive.

Volatile substances were separated from mulberry leaves by steam distillation. Approximately twenty types of compound were identified as derivatives: alcohols as 3,5-dinitrobenzoates; aldehydes and ketones as 2,4-dinitrophenylhydrazones; and acids as p-phenyl phenacyl esters[3–6].



No attractant Attractant—neutral fraction (b.p. 120–170° C.)

Fig. 1. Attractivity of the essential oil from mulberry leaves for the silkworm larvæ



No attractant Attractant—β-γ-hexenol

Fig. 2. Attractivity of β-γ-hexenol

The neutral fraction from the essential oil of mulberry leaves, especially that with b.p. 120–170° C., attracted silkworms[1]. *n*-Butanol and β-γ-hexenol were detected as alcohols[5], and *n*-butyraldehyde, *iso*butylaldehyde, *n*-valeraldehyde, α-β-hexenal and methyl-ethyl ketone as aldehydes and ketones in this fraction[3,4]. All the compounds other than β-γ-hexenol and α-β-hexenal had already been tested as to their effects on the chemotaxis of silkworm larvæ.

β-γ-Hexenol and α-β-hexenal could not be obtained in the free state from mulberry leaves. These compounds were obtained from the essential oil of *Mentha rotundifolia* L. according to the method of Takei[7]. β-γ-Hexenol attracted the silkworm larvæ strongly. α-β-Hexenal, made by oxidation of β-γ-hexenol, also showed attractivity.

From these experiments it was concluded that the compounds in mulberry leaves which attracted the silkworm were β-γ-hexenol and α-β-hexenal. The larvæ when young tend to be attracted to β-γ-hexenol, and to α-β-hexenal when older.

I am much indebted to Prof. G. S. Fraenkel for helpful discussion.

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Reversal by Magnesium Ions of the Inhibition of Yeast Metabolism by a Cationic Detergent

It has been shown[1,2] that cationic detergents strongly inhibit the production of acid and of carbon dioxide by unbuffered suspensions of baker's yeast. It has also been found[2] that the addition to such suspensions of inhibitory concentrations of cationic detergents is followed by extensive lysis of the cells. The suggestion has been made[2] that interaction between detergent cations and anionic groups in the cell surface is an essential factor in the lytic and inhibitory action of cationic detergents on yeast. It seemed possible, therefore, that the inhibition of yeast metabolism by these compounds might be considerably modified in the presence of appropriate concentrations of univalent and bivalent metallic cations which have been shown[3] to combine with at least two types of fixed anion in the yeast cell surface.

The effect of magnesium ions (added to the system as magnesium sulphate) on the inhibition of the aerobic carbon dioxide output of a 1 : 20 suspension (in 5 per cent glucose) of baker's yeast by the cationic detergent dodecyl trimethyl ammonium bromide is shown in Fig. 1. Curve 1 of this figure shows the effect of increasing concentrations of magnesium sulphate in the presence of 0·0025 *M* detergent. It is seen that the degree of inhibition decreases from about 93 per cent in the absence of salt to less than 40 per cent in the presence of 0·004 *M* magnesium sulphate. Curve 2 shows the effect of magnesium sulphate, over the same concentration range, on the inhibitory action of a slightly smaller concentration of detergent (0·002 *M*). In this case the degree of inhibition was reduced from some 85 per cent in the absence of salt to about 10 per cent in the presence of 0·004 *M* magnesium sulphate.

It appears that this effect is observed only when the salt is added to the suspension before or at the same time as the detergent. It is seen from Fig. 1 (curve 4) that the addition of magnesium sulphate (up to 0·003 *M*) to yeast suspensions which had been exposed, for 30 min., to 0·0025 *M* dodecyl trimethyl ammonium bromide did not result in any observable increase in fermentative activity.

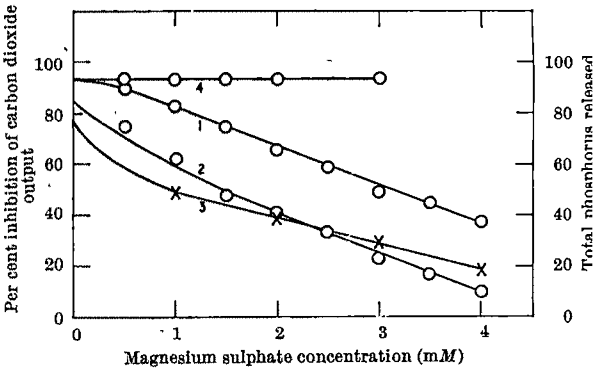

Fig. 1. Effect of magnesium sulphate on the inhibition by dodecyl trimethyl ammonium bromide of the aerobic production of carbon dioxide by baker's yeast (curves 1, 2 and 4). Yeast suspension; 1 part by weight in 20 vol. suspension fluid containing 5 per cent glucose. Detergent concentrations; 0·0025 *M* (curves 1 and 4) and 0·002 *M* (curve 2). Curves 1 and 2, detergent and salt added simultaneously to suspension. Curve 4, detergent added 30 min. before salt. Curve 3, effect of magnesium sulphate on the release of total phosphorus (expressed as a percentage of the amount extracted from the cells by 10 per cent trichloracetic acid) from yeast cells by dodecyl trimethyl ammonium bromide. Yeast suspension, 1 : 20 without glucose

The effect of magnesium sulphate on the lysis of yeast cells by 0·002 *M* dodecyl trimethyl ammonium bromide is shown in curve 3 of Fig. 1. In these experiments lysis was measured in terms of the total amount of the phosphorus released from the cells, this being expressed as a percentage of the total phosphorus extracted from them by 10 per cent trichloracetic acid[2,4,5]. It is seen that there is a progressive decrease in the degree of lysis with increasing magnesium sulphate concentration and that there is a fairly close correlation between the effect of magnesium sulphate on the lytic activity of the detergent and on its inhibitory action on yeast metabolism.

That the reversal, by magnesium sulphate, of the inhibitory action of dodecyl trimethyl ammonium bromide on the aerobic carbon dioxide output of yeast described above may be ascribed to an effect, on the cells, of the magnesium ion is indicated by the fact that similar results are obtained in the presence of other metallic cations which do not themselves inhibit yeast metabolism, and that these results do not appear to depend, to any marked extent, on the nature of the added anion. In the case of salts of bivalent metals (for example, calcium chloride, strontium nitrate, barium chloride, ferrous sulphate, cobalt chloride) the results obtained indicate that the ability of bivalent cations to reverse the inhibitory action of dodecyl trimethyl ammonium bromide on yeast metabolism is, in general, of the same order as that of magnesium ions. The univalent ions tested (lithium, sodium, potassium and ammonium) appeared to be considerably less effective than magnesium ions while the trivalent lanthanum ion showed markedly greater activity than magnesium.

I consider that these results may be interpreted as indicating that magnesium and other metallic cations can, under appropriate conditions, compete with dodecyl trimethyl ammonium bromide for fixed anionic sites on the yeast cell surface.

These experiments were carried out during the tenure of a fellowship of the Medical Research Council of Ireland at the Department of Physiology, University College, Dublin. They will be published in detail elsewhere.

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Survival of Intact Insects immersed in Liquid Oxygen without any Antifreeze Agent

It is well known that various organisms can be cooled to very low temperatures in liquid gases without injury, provided that they have previously been desiccated to some extent. Extracellular freezing is considered to be a mode of dehydrating living cells; and some organisms, at least frost-resistant ones, may withstand freezing of this type even at very low temper[illegible]s. On the other hand, many living organisms [illegible]e slow cooling to extremely low temperatures[1]. This might also be explained by dehydration due to extracellular freezing. In these cases, however, the materials used were usually isolated cells or very small pieces of tissue. The largest entire animal hitherto found to survive freezing at a very low temperature is the tiny vinegar eel[2]. Our experiments show that, after sufficient extracellular freezing, an intact insect can be kept alive at an extremely low temperature without any antifreeze agent.

We used a 'slug caterpillar', *Cnidocampa flavescens* (Walk.) in the overwintering prepupal stage, when these insects form hard cocoons in which they complete their metamorphosis in the succeeding summer. The naked prepupal larvæ from the cocoons usually range from 250 to 450 mgm. in weight; they are very resistant to intense cold as well as to prolonged body freezing[3]. The freezing process of the larva is probably as follows[4]. At first, when cooled below about – 20° C., the blood freezes rapidly and then extracellular freezing of the tissue cells occurs. The tissue cells undergo dehydration and contraction; nevertheless they usually withstand such severe conditions for a long period, provided the rate of cooling is not too great.

In our experiments the larvæ in their cocoons were first frozen in a special refrigerator, in which the air temperature was lowered from – 5° to – 90° C. in 1½ hr. and maintained at that temperature for 45 min. The insects were then rewarmed in air at room temperature. After thawing, about one-third of the sixty larvæ revived.

This result suggested that, after partial dehydration due to extracellular freezing, the insect might survive even rapid cooling to a very low temperature, and encouraged us to try freezing the same animal in liquid oxygen after preliminary freezing at graded temperatures.

100 insects were divided into five groups, each of ten larvæ in intact cocoons and an equal number from which the cocoons had been removed. The first group was stored at 0° C. The second was kept for one day at – 10° C., at which temperature the insect never freezes spontaneously[3]. The third was also kept at – 10° C. for one day after the larvæ had been subjected to freezing at – 20° C. The fourth and the fifth groups were held for one day at – 20° C. and – 30° C. respectively, at which temperatures the larva usually freezes within 40 min. All five groups of insects were then immersed directly in liquid oxygen. After being kept there for a full day, they were held in air at – 30° C. for 4 hr. and then transferred into air at room temperature. Among the five groups, revival of the insects after thawing occurred only in the last. Of ten naked larvæ, nine recovered the active movement of the heart which was easily visible through the dorsum. None of them, however, pupated even after incubation at 20° C. for fifty days, nor did the larvæ in intact cocoons, at least within fifty days of incubation. Control insects, stored at 0° C. and then incubated at 20° C., usually completed metamorphosis within fifty days.

A preliminary experiment showed that the tissue cells of this larva are not affected by freezing for several days at – 40° C., provided that the ice formed is extracellular. In the larvæ of the fifth group, most of the tissue cells appeared to be quite normal immediately after thawing except for the fat cells, in which the small fat granules of uniform size sometimes fused into larger homogeneous masses. In the larvæ of all the other groups a remarkable destruction of the fat body usually took place, and when the insect body was dissected numerous small oil droplets, which had flowed out from the fat cells, were observed on the blood surface. In this case some of the tissue cells probably froze intracellularly, whereas in the fifth group most of the cells must have frozen extracellularly. It is therefore reasonable to suppose that if the insects are previously frozen extracellularly at – 30° C., scarcely any water crystallizes in the tissue cells even at an extremely low temperature.

Similar results were obtained from experiments on the overwintering larva of a butterfly, *Aporia crataegi adherbal* Fruhstorfer. The body-weight of this larva was about 1·7 mgm. Two groups of about fifty larvæ in the hibernacula were frozen at – 20° C. and – 30° C. respectively for one day and then immersed directly in liquid oxygen for a full day. After thawing in air at room temperature, all the larvæ prefrozen at –20° C. were found to have been killed, whereas most of the larvæ prefrozen at – 30° C. recovered their motility and have been growing normally on the leaf of apple, the food plant.

Further details of this work will be published elsewhere.

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Ultra-structure of the Coxal Glands of the Scorpion

ALTHOUGH much is known, nowadays, about submicroscopic structures of the vertebrate kidney, we still have very poor information on the ultra-structure of invertebrate excretory organs.

Beams *et al.*[1] have studied the cells of grasshopper Malpighian tubules with the electron microscope. They also referred to unpublished evidence concerning the 'nephron' tubule cells of the crayfish. In both cases it appears that some particular features are common to these excretory cells and to vertebrate nephron cells. The most characteristic of these features is the great amount of mitochondria between double membranes which are infoldings of the basal cell membrane.

Coxal glands of the scorpion are embryologically homologous to the kidneys of the crayfish. As a part of a more comprehensive study of their anatomy, cytology and physiology, we investigated the ultra-structure of these organs.

The gland, which is more or less spherical, consists of two parts : (1) a medulla, which has much the same structure as the glomus of a vertebrate nephron but is, of course, devoid of any capillary endothelium, and (2) a cortex, consisting of one single convoluted tubule, arising from the central glomus, and twisted and coiled around it so as to give the whole gland a brain-like appearance. The wall of the tubule is a one-layer epithelium of flat prismatic cells. Even at optical magnifications, these cells have much the same appearance as those of the proximal convoluted tubule of the vertebrate nephron.

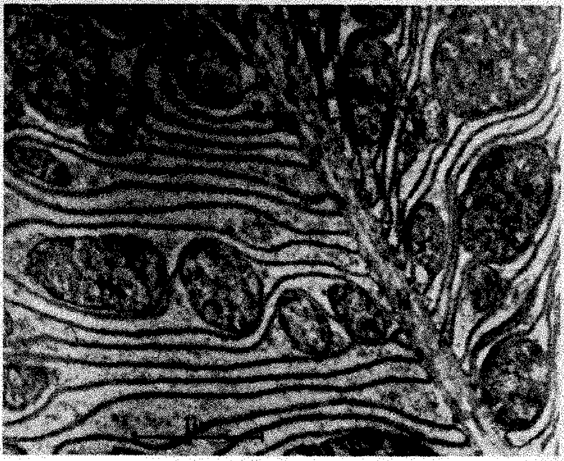

Fig. 1. Basal β-cytomembranes in two coxal gland cells of *Euscorpius carpathicus*. *H*, Hæmolymphatic space between the cells of two adjacent tubules ; *M*, mitochondria (in a fed animal)

On electron micrographs the similarity is striking. (1) In the basal half of the cells a crowd of mitochondria is intricately aligned in narrow compartments and separated by double membranes. (2) These membranes appear to be in every respect similar to those described by Sjöstrand and Rhodin[2] and later called 'β-cytomembranes' by Sjöstrand[3]. They are very narrow infoldings of the thin osmiophilic cell-membrane, running deep into the cell from its base. (3) At the very base of the cell, just outside this folded membrane, there is another membrane. This poorly defined, less osmiophilic layer, is probably the basement membrane of the epithelium. From optical sections, it appears to be continuous with the membrane of the glomerular wall. (4) The mitochondria are disposed in the same way as in vertebrate nephron cells. Nevertheless, their shape is quite different. Instead of being long and cylindrical, with more or less regularly spaced parallel cristæ[4], they are ovoid, with diameters of about 0·5 and 1·5μ. Their inside is a confused mass of twisted irregular cristæ, giving the whole mitochondrion a dense appearance. (5) The upper half of the cell contains a giant nucleus and a few mitochondria. They are scattered throughout the cytoplasm, particularly right under the free limit of the cell. (6) This apical limit is differentiated into a typical brush border. On electron micrographs this border clearly consists of a covering of very long microvilli, densely packed together over the whole surface. The optical microscope shows that the brush-border only extends over the proximal part of the convoluted tubule, that is, on the segment nearest the central glomus. (7) A comparison between coxal glands of starving and well-fed scorpions has shown a great difference between their respective mitochondria. In unfed animals, only a few, well-defined cristæ project into the mitochondrion, in a matrix that appears quite transparent to electrons. Rouiller and Gansler[5] showed the same kind of difference between the mitochondria of the proximal convoluted tubule in normal and starved rats.

The close similarity existing between the ultra-structure of the coxal glands and that of other organs which are known to be excretory suggests that the coxal glands should also be regarded as excretory organs. Although this has been assumed hitherto, it was never demonstrated convincingly. In further work one of us will collect more evidence about the exact function of the gland.

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Immuno-chemical Observations on the Intimate Structure of Human Albumin

Marrack and Orlans[1], in a careful study of the behaviour of bovine albumin before and after acetylation, demonstrated that the acetylated product interacted with an antibody globulin prepared against the unmodified bovine albumin.

In a detailed study of globulins isolated from patients suffering from myelomatosis it was noted that individual globulins, homogeneous by electrophoretic and ultracentrifugal analysis, and demonstrably different from one another by these criteria, showed a common behaviour to specific antibodies to the γ_2-globulins using the technique of Ouchterlony or Oudin[2].

These observations prompted us to examine to what extent and in what way a well-characterized human albumin might be modified without materially altering its behaviour to an antibody specific to it in its natural unaltered state.

In a detailed study of the interaction of native and specifically modified albumin with metals in this laboratory, Perkins[3] had prepared a number of modifications of human albumin. Of these we examined three, choosing them because of their satisfactory analysis in the ultracentrifuge and by electrophoresis. The first modification was an acetylated albumin in which analysis indicated that about sixty amino-groups had been replaced by —NHCOCH$_3$. The second and third modifications were the products of interaction of human albumin with bromacetic acid and β-bromopropionic acid respectively. Analysis of the bromacetylated derivative indicated that thirty-six amino-groups had been substituted. The evidence from the behaviour of the protein with various metals suggested that the substitution involved the replacement of both hydrogens in the amino-groups to give —N(CH$_2$COOH)$_2$.

The bromopropionic derivative involved sixty-three amino-groups, the substitution most probably being that the free —NH$_2$ had been converted to —NH(CH$_2$)$_2$COOH.

The original batch of human albumin used in this work gave a value of eighty-seven free amino-groups in 10^5 gm. of protein.

The original albumin and the three modifications were examined by the micro-immunochemical technique of Cleve and Schwick[4] based on the method of Grabar and Williams[5].

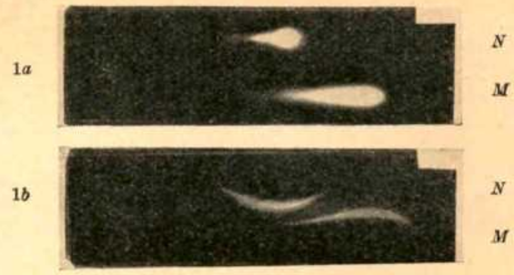

Fig. 1. Acetylated albumin. *a*, Electrophoretic analysis in agar. Analysis carried out at 20°, 2 V./cm. for 2 hr., in glycine buffer *p*H 8·4, ionic strength 0·05. *b*, Immuno-electrophoretic analysis in agar. Analysis carried out as above, followed by development with specific antisera for 18 hr. at 25°

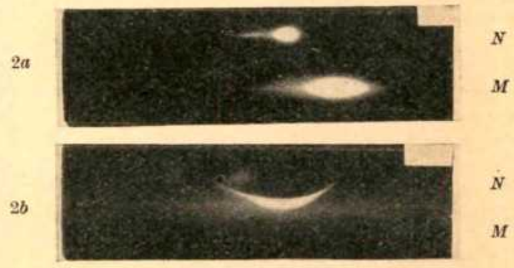

Fig. 2. Albumin modified with bromacetic acid. *a*, Electrophoretic analysis in agar, as in 1*a*. *b*, Immuno-electrophoretic analysis in agar, as in 1*b*

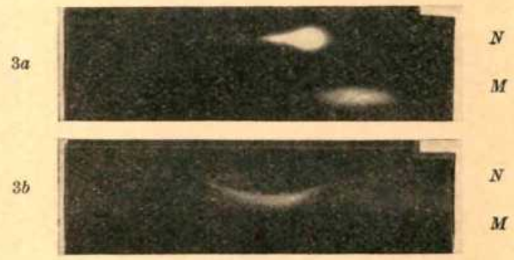

Fig. 3. Albumin modified with bromopropionic acid. *a*, Electrophoretic analysis in agar, as in 1*a*. *b*, Immuno-electrophoretic analysis in agar, as in 1*b*

N, Native albumin; *M*, modified albumin

The replacement of 69 per cent of the free amino-groups with acetylated amino-groups in the first modification materially alters the net charge of the albumin and as a consequence its mobility. This is clearly indicated in Fig. 1*a*. The interaction with antiserum specific for unmodified human albumin is shown in Fig. 1*b*.

From these figures it is clear that proteins may differ markedly in their net surface and in their electrophoretic mobility, and yet retain their capacity to react with specific antisera.

The great proportion of the free amino-groups in albumin are the epsilon amino-groups of lysine. There is no reason to suppose that the majority of the lysine residues are concentrated in one area of the chain; therefore, to have acetylated 69 per cent of the available free amino-groups seems to imply a modification over a considerable surface area of the molecule without altering its capacity to interact with the specific antibody.

Fig. 2*a* shows the relative migration of the unmodified albumin and of the albumin after modification with bromacetic acid (lower spot). Fig. 2*b* shows the well-defined crescent of interactions between the unmodified albumin and antisera specific for unmodified albumin using the immunochemical technique and on the same plate a parallel analysis of albumin modified by bromacetic acid, which fails to react with the specific antisera to produce a precipitate. Albumin modified by bromopropionic acid (Figs. 3*a* and *b*) behaved in the same way as albumin modified by bromacetic acid.

In the second and third modifications the free amino is replaced not by a non-polar group but by a carboxyl carrying a negative charge. There is, therefore, an alteration in net charge not from the reduction in the total of existing positively charged groups but by the replacement of certain of the positively charged with negatively charged groups. This may have a much greater effect on the secondary structure of the protein by redistributing the pattern of surface charge and may actively interfere with the normal hydrogen bonding within the chain. The resulting re-orientation would explain the failure of the modified protein to react with the antisera.

We wish to thank the Research Committee of St. George's Hospital, the funds of which supported part of this work.

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Lunar Periodicity of Aquatic Insects in Lake Victoria

DESPITE the constancy of their environment, certain aquatic insects in Lake Victoria exhibit periodic emergence. In the mayfly, *Povilla adusta*, emergence is closely synchronized and occurs shortly after full moon[1]. On the other hand, most swarms of 'lake-flies' (unidentified Chironomidae and *Chaoborus*) have been reported to occur shortly after new moon[2].

To investigate this matter further, a Robinson-type insect trap[3], fitted with a 125-W. mercury vapour bulb, was run near the lake-shore at Jinja (lat. 0° 25·5′ N.) for a hundred consecutive nights. The numbers caught each night of certain species of Plecoptera, Ephemeroptera, Trichoptera, Chironomidae and *Chaoborus* were counted or estimated, a procedure made feasible by modifying the trap so as to admit only about a quarter of its normal catch.

Of the thirty-seven species studied, four (apart from *P. adusta*) showed a periodic fluctuation in numbers correlated closely with the age of the moon. These species differed, however, as to the position of the peak of abundance in the lunar cycle and as to the amplitude of the fluctuation. Results for these species and for *P. adusta* are given in Table 1.

Table 1. LUNAR PERIODICITY OF FIVE AQUATIC INSECTS IN LAKE VICTORIA

Group	Species	Age of moon to nearest day	
		Abundance peak	Range of captures
Ephemeroptera : Polymitarcidae	*Povilla adusta* Navas	17–18	15–4
Trichoptera : Leptoceridae	*Athripsodes stigma* Kimmins	23–29	Every day
	Athripsodes ugandanus Kimmins	8–9	Every day
Diptera : Chironomidae	*Clinotanypus claripennis* Kieffer	7–8	28–11
	Tanytarsus balteatus Freeman	2–5	Every day

In addition, the estimated abundance of *Chaoborus edulis* Edwards (probably including a few *C. pallidipes* Theo.) also fluctuated in phase with the moon. Numbers rose abruptly to a peak five to two days before new moon (that is, at a moon age of 24–27 days), and thereafter fell gradually, so that there were several nights during the fortnight preceding a peak on which no specimens were found.

That catches in a light-trap may reflect activity as well as emergence or abundance of insects has frequently been emphasized, and it is important where possible to assess the relative effects of these factors. The asymmetrical pattern of abundance of *C. edulis* gives a firm indication that here it is caused primarily by a corresponding rhythm of emergence rather than activity. Observations of five day-time swarms of *Chaoborus* at Jinja, all of which have been 4–2 days before new moon, support this.

The more symmetrical pattern of abundance of *Tanytarsus balteatus* (Fig. 1) might appear at first to support the idea, recently discussed[4], that catches in a light-trap are greatest near new moon and least near full moon owing to an artefact effect resulting from changes in the relative brightness of the trap at different phases of the moon. However, positions of the peaks and troughs relative to new and full moon do not confirm this interpretation, and it appears more likely that the pattern is caused by a lunar rhythm of emergence in which the population is poorly synchronized. The same is possibly true of *Athripsodes stigma* and *A. ugandanus*.

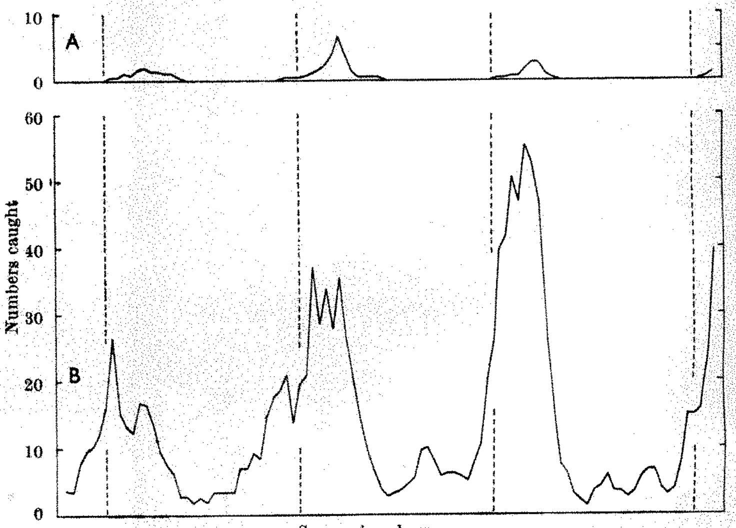

Fig. 1. Numbers caught nightly of (*A*) *Clinotanypus claripennis* and (*B*) *Tanytarsus balteatus* in relation to new moon (shown by vertical dotted lines). Results smoothed by a sliding geometric mean of 3

In the remaining species studied, no cyclical fluctuation in numbers could be discerned. This has two implications of interest: first, it demonstrates that emergence and reproduction of many aquatic insects in equatorial lakes need not be cyclical; and second, it shows that, in the groups studied, the hypothetical artefact effect mentioned above does not influence catches in a light-trap to a significant extent.

It is intended to publish a full account of this work elsewhere.

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Preservation of Grass for Winter-feeding by Radiation Sterilization

IN the course of investigations on microbial decomposition of grass carried out at Hurley by one of us (E. G.), a method of sterilization was sought which would not alter appreciably the chemical and physical structure of grass. Ionizing radiation gave the most promising results. It was then decided to explore the possibilities of preserving grass for winter-feeding on a purely experimental basis by this method. A preliminary account by Grossbard *et al.*[1] was published in 1957. Radiation sterilization of meat, dairy products, grain and other materials has been studied extensively. The results have been reviewed by Hannan[2], Comar[3] and others.

Irradiation of small experimental samples (50–100 gm.) of ryegrass (*Lolium perenne*) tightly packed in cylindrical containers of polystyrene were carried out at the Wantage Radiation Laboratory. A cobalt-60 source was used and dosages of 1×10^6 to 4×10^6 rads were applied. Extensive sterility tests showed that a dose of 2×10^6 rads $\pm$ 10 per cent was adequate for complete sterilization. This agrees with the findings of other workers using different biological materials.

The samples were stored for periods of 6–18 months. Irradiation in itself did not cause any conspicuous changes in the physical appearance of the grass. However, a characteristic though not unpleasant odour developed immediately after irradiation. Samples kept in the dark at 4° C. retained their green colour up to six months, while those stored in the light at laboratory temperatures turned a straw colour after two to three months. Possibly factors other than temperature and light will affect persistence of chlorophyll.

Recently, exploratory experiments were carried out on larger samples ranging from 500 to 2,000 gm. tightly packed in polyethylene bags or tinned cans. A total of 30–40 kgm. was irradiated at any one time either from a cobalt-60 source or a 4-MeV. linear accelerator. The results obtained using the accelerator were inconsistent in themselves owing to the difficulty of measuring the dose delivered to the grass.

Batches of this irradiated grass were then fed to experimental sheep. A total of six animals was used for this test. Whether this grass was fed immediately following irradiation or after a month of storage the sheep soon became accustomed to it. While our results are of necessity on a small scale, it appears that irradiation in itself does not interfere appreciably with the palatability of the grass.

It is intended to irradiate larger bales of grass in the spent fuel-rod assembly at the Atomic Energy Research Establishment, Harwell, and to carry out more extensive trials on palatability, digestibility and the nutritional value of irradiated grass.

Another problem which is under investigation is a suitable container in which to pack and store the grass. We find that in polyethylene bags recontamination readily occurs, possibly owing to changes which have taken place in the plastic as a result of irradiation. Small sample bags of 'Metathene' (a polyethylene-'Cellophane' laminated film produced by the Metal Box Co.) filled with grass and placed inside the polyethylene bags also containing grass were more resistant, and while recontamination occurred on storage the percentage was lower than in polyethylene bags. So far the tin cans proved to be the most suitable containers.

We wish to thank Mr. W. F. Raymond for his interest in this work and Mr. G. E. Outen for valuable technical assistance.

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Polarization of Light of the Comets Arend-Roland (1956*h*) and Mrkos (1957*d*)

POLARIZATION of the total light of the Comets 1956*h* and 1957*d* was studied photographically by simultaneous exposures with three objectives and three 'Polaroids'. The planes of polarization of the three 'Polaroids' were at 120°. 2-in. objectives were used at $f/9$ with Agfa 'Astro' panchromatic plates. The characteristic curve was determined by comparison with an exposed photometric wedge. Errors due to the instrument were measured by means of light from an artificial source, polarized to a known degree by reflexion from a glass surface. The error of the polarization determined is $\pm 2 \cdot 5$ per cent.

Altogether we obtained seven plates of the Comet 1956*h*, during April 27–May 29, 1957. Only five of them, however, were suitable for detailed measurement. The Comet 1957*d* was photographed three times, but only two of these plates, during August 20–23, 1957, were measured. This was done with a self-recording microphotometer, using a square slit with an area of $0 \cdot 005$ mm.^{2}. In the case of the Comet 1957*h*, where the phase-angle θ was 58° or 69°, respectively, the values found were reduced for $\theta = 90°$. The results of our measurements are shown in Tables 1 and 2.

Table 1. Degree of Polarization (per cent) of the Light from Comet Arend-Roland 1956*h*

Date (1957)	Phase angle, θ	Distance from the head (min. of arc)								
		3	4	5	6	8	10	12	14	16
April 27	98	18·9	22·4	23·5	23·2					
,, 27	98	21·7	21·9	23·4	23·8	26·6	27·1			
,, 29	92	11·2	14·9	15·2	17·4	18·5				
May 1	85	11·9	15·1	17·2	15·2	20·7				
,, 2	81		12·8		15·7	18·2	17·5	19·1	18·9	19·2

Table 2. Degree of Polarization (per cent) of the Light from Comet Mrkos 1957*d*

Date (1957)	Phase angle (θ)	Distance from the head (min. of arc)				
		3	4	5	6	8
August 20	63	10·8	10·5	10·5	10·8	
,, 23	59·5	10·8	8·2	8·4	7·7	10·9
		For phase angle θ = 90°				
,, 20		14·1	13·7	13·7	14·1	
,, 23		15·1	11·3	11·6	10·7	15·3

Using these results, we came to the following conclusions: (1) The degree of polarization in the tail of the Comet 1956*h* decreases towards the head, but is fairly constant at large distances from the coma. (2) There was a sudden decrease of the degree of polarization in the whole tail of the Comet 1956*h* between April 27 and 29. (3) The degree of polarization in the tail of the Comet 1956*h* agrees with values found by other observers[1–3], though that of Barber[4] is extremely high compared to ours. (4) The degree of polarization in the tail of the Comet 1957*d* is distinctly lower. In contradiction to the results of Barber[4], the polarization of light from this comet may be explained as predominantly due to pure molecular emission. On the other hand, the higher values found for Comet 1956*h* may be explained by an increased proportion of light scattered by dust particles. This also agrees with the published spectrographic results, which indicate that the continuous spectrum was also extraordinarily prominent in Comet 1956*h*. The colour index, measured by Tremko and Vanýsek[5], was found to be + 0·59 in the *BV* system for the Comet 1956*h*, very close to the colour index of the Sun, but it was as low as + 0·19 in the light of Comet 1957*d*.

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Correlation of Whistlers and Lightning Flashes by Direct Aural and Visual Observation

Extending the theoretical work of Eckersley[1], and combining it with extensive experimental observations, Storey• deduced that whistlers result from the energy of very low frequency radiated by lightning flashes, propagated up to great heights along the flux of the Earth's magnetic field and down again to the ground at the geomagnetically symmetrical place in the opposite hemisphere, taking a second or two to make this very long trip. The lower frequencies travel more slowly than the high, so that the original impulse is spread out into a swish or whistler of descending pitch when it is received[2].

Allcock and I have reported that the simultaneous observation of whistlers at conjugate points in the northern and southern hemispheres bears out the essential details of Storey's hypothesis, and Helliwell and Gehrels have found that very low-frequency broadcast signals can be received in the opposite hemisphere after propagation in the whistler mode[3].

Helliwell, Gallet and Ellis have each noted independently that, above a certain frequency, the dispersion must reverse. This was first verified by Helliwell[4,5].

Throughout this development, there has remained the disquieting fact that nearly all known attempts to observe lightning by visual perception and to hear a resulting whistler have been unsuccessful. Eckersley reported that "K. Tremellen has found that Isolated Whistlers are definitely caused at certain times by local lightning flashes"; and Dinger and I have communicated an observation by A. G. Jean[1,6]. Because these reports have not been sufficiently elucidated, or readily duplicated, there have been persistent suggestions that whistlers may not be generated by lightning.

In 1957, on May 27 at about 0215 *Z* at Hanover, N.H., I noted a distant lightning flash in the night sky. Turning to a whistler receiver I heard almost continuous whistler activity. The whistlers were the long or round-trip type, followed by echo trains. Their intensity was not great, and it was not possible at that time to detect any correspondence with the visible lightning flashes which were continuing. In time, the storm producing the flashes came closer until thunder could be heard. By then, I observed that some flashes were producing weak whistlers, but the majority still were not. As the storm continued its advance, the flashes became less frequent and the resulting 'sferics' became noticeably shorter in duration and greater in intensity (by aural perception). By about 0500 *Z*, every visible flash was producing a strong whistler with several echoes and there were no other whistlers present. Flashes were occurring about three minutes apart and there were no other 'sferics' present except a steady barrage of very weak tweeks.

This situation persisted for about an hour, after which the flashes became still less frequent and I finally saw no more. Coincidentally I heard no more whistlers. Throughout, the clouds hung low and there was much mist near the ground. Heavy rain fell at times. Although the flashes lit up the countryside, I could not see the discharge paths from my position.

From this successful observation, and many unsuccessful ones of the past, it is concluded:

(1) that lightning flashes can generate whistlers, (2) that most lightning flashes do not generate whistlers.

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A Simple Device for observing the Polarization of Light from the Sky

Chapman[1] has recently described a device for visualizing the pattern of plane-polarized light from blue sky, which seems to be unnecessarily complicated and expensive.

The ability of certain animals to perceive the polarization of light is not entirely absent in man. In the human eye polarized light causes an 'entoptic' phenomenon called Haidinger's brushes. This consists of two yellow sheaves radiating in opposite directions from the point of fixation. The sheaves are flanked by blue hyperbolic regions. The axis of the blue hyperbola corresponds to the plane of vibration of the electric vector of linearly polarized light, which is at right angles to the 'plane of polarization'. It is quite easy to see Haidinger's brushes by rotating a polarizer slowly before the eye, but to use the phenomenon to study the polarization of the light from the sky is difficult as the percentage of polarized light is never very large. After some training it is, however, often possible.

A simple sky-compass was constructed by Tschermak-Seysenegg[2] from a rectangular piece of 'Polaroid' with the optical axis parallel to one of the sides of the rectangle. From this are cut out (as shown in Fig. 1) 12 isosceles triangles with their bases parallel to the long side of the rectangle and with their top angles 30°. These triangles are then arranged to a regular dodecagon. If one looks at the sky through this 'radial analyser' light and dark sectors are seen, as with Chapman's device.

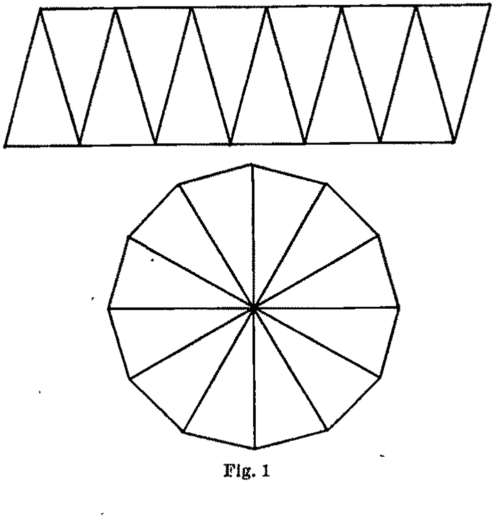

Fig. 1

The sensitivity of this simple apparatus is increased by combining the 'radial analyser' with a 'radial retarding plate'. I have used 'Cellophane'[3] as the birefringent material. Double layers of 'Cellophane' are pasted on a piece of 'Polaroid'. The optical axis of the tape (which is parallel to the fine striation of the material) is kept at 45° to that of the 'Polaroid'. The whole is then cut into triangles and arranged to form a dodecagon as above. In this way the sectors appear yellowish-green and purple and are easy to observe even if the percentage of polarized light is small.

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Verdet Constants of Rare-Earth Glasses measured with a New Polarimeter

In some optical devices the Faraday effect is used with advantage as a shutter, and, as a modulator of a light beam, it is especially useful in polarimetry[1–3]. In such applications a material having a large value of the Verdet constant is usually sought, consistent with adequate transmission at the desired wavelengths. While numerous materials, especially thin metal films and ferrites, are known which have large absolute values of the Verdet constant[4], measurements reported here are limited to glasses.

From the data published by Cole[5] the Verdet constants of silicate glasses not containing rare-earths are seen to be approximately proportional to the reciprocal of their constringence, and positive. Therefore, a low-power magneto-optic modulator using the Faraday effect has often depended upon the use of a dense flint glass of low constringence.

It was discovered here that there is at least one readily available glass the Verdet constant of which is negative : didymium filter glass, type *ON*16 (Chance-Pilkington Optical Works, Ltd.). The negative Verdet constant of this glass raised the question of how the Verdet constant would depend upon the presence of a paramagnetic rare-earth in a glass.

A preliminary examination with a visual polarimeter of some experimental glasses, obtained from the research laboratories of Messrs. Pilkington Brothers, Ltd., was then made. These glasses contained a constant proportion of boric oxide, and samarium oxide replacing lanthanum oxide from 0 to 65 per cent by weight. It was found that their Verdet constants, while positive in sign, decreased with increasing samarium content.

Finally, the Verdet constants of a number of borate glasses specially made by the above Research Laboratories and containing graded proportions of the paramagnetic rare-earths gadolinium and dysprosium were measured using the recently available *ETL-NPL* automatic polarimeter.

The operation of this polarimeter has been described elsewhere[6], but it should be noted that the activity of a sample in this polarimeter appears as an analogue electric current. In these experiments this current was measured using an adjustable shunt and a potentiometric chart recorder.

The optical activity was measured using an incandescent source filtered in the neighbourhood of mercury green with a half-intensity width of 200 A. A reduced aperture was used so that the beam crossing the sample had a diameter of 2 mm.

The various samples were polished plane-parallel to thicknesses between 2 and 3 mm., and were left as fragments of less than $\frac{5}{8}$ in. in any other dimension.

An axial magnetic field of about 1,120 gauss was provided in a sample holder which used two axially polarized permanent magnets of an annular shape. The flux path of each magnet was nearly completed with turned soft-iron washers having a conical inside surface perforated with a central $\frac{1}{8}$-in. hole, and leaving an axial gap of $\frac{1}{8}$ in. to contain the sample. Two such assemblies with their magnetic fields in opposition were mounted within a plastic holder having an outside diameter of 30 mm. Only one magnet assembly was used to contain the sample, and the magnetic fields of the two tended to cancel, so that the effect of stray magnetic fields upon the polarimeter was reduced to less than 0·008° arc and could be corrected for. During the course of some fifty measurements where the sample holder was dismantled and re-assembled each time, the effective field-strength H was found to have decayed by less than 1 per cent.

The effective field-strength H in the perforated gap of the sample holder can be found by referring the observed magneto-optic rotation of fused quartz α_q to the known Verdet constant V_q of fused quartz[7] (16·64 min./kilogilbert):

$$H = \alpha_q / V_q p_q \qquad (1)$$

where p_q is the path-length. Measurements of the Verdet constants of the rare-earth glasses were then made referring to the Verdet constant of fused quartz. Thus, if the observed sample rotation α_s in a path-length p_s corresponds to a sample Verdet constant V_s:

$$V_s = \alpha_s / H_s p_s \qquad (2)$$

Upon substituting the value of H from (1) then,

$$V_s = V_q(\alpha_s/\alpha_q)\ (p_q/p_s) \qquad (3)$$

Chart records of the optical activity of the fused quartz reference and of the sample glasses were usually made alternately, and the ratios of optical activity taken from adjacent traces. The chart record was also convenient in observing the birefringence of the samples, as an oscillatory trace was obtained when the sample holder, together with the sample in it, was slowly turned about the optical axis. The activity of the sample was then taken as the average value of the trace over at least four cycles.

In all cases the birefringence greatly exceeded the inherent noise-level of the instrument, which was 0·001° arc in a 1 c./s. bandpass. The total excursion of the recorder trace due to residual birefringence is recorded in Table 1 as per cent of the mean optical activity.

The Verdet constants of the six new rare-earth glasses are listed in Table 1. The six samples all contained 37·5 per cent by weight boric oxide, and the balance both lanthanum and the paramagnetic rare-earth oxide.

For the comparison, the Verdet constant of a didymium filter glass, and the most dense flint glass available for construction of a Faraday cell, are included in Table 1.

Table 1

Glass	V_s (min./kilogilbert) λ = 546 nm.	Mean deviation (per cent)	Amplitude of birefringence (per cent)
Didymium *ON* 16	−25·3	1·2	18·0
10 wt. per cent Gd_2O_3	21·2	5·6	43·0
20 ,, ,, ,,	20·5	4·6	64·0
30 ,, ,, ,,	19·8	2·2	25·2
10 ,, ,, Dy_2O_3	−35·2	3·7	22·0
20 ,, ,, ,,	−93·8	3·0	12·8
30 ,, ,, ,,	−150·0	2·7	6·7
030181	151·0	—	—

These results show that certain glasses can have negative Verdet constants comparable in magnitude with that of the densest flint glasses.

It would be interesting to find out in more detail just how the presence of the paramagnetic rare-earth ion is related to the Verdet constant, and whether much greater Verdet constants could be obtained.

I am indebted to Mr. J. Kowal for making many of the measurements reported here, and to the Controller of Research, Dr. J. H. Mitchell, for permission to publish this paper.

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Ordering in Liquid Mercury–Thallium Alloys containing 25–35 Atomic per cent Thallium

Recent X-ray measurements on liquid mercury–thallium alloys have given some evidence for ordering at compositions corresponding approximately to the solid-state compound Hg_5Tl_2 [1]. These results, obtained at 17° C., some 3° C. above the melting point of Hg_5Tl_2, are unfortunately inconclusive due to the uncertainty introduced by the extensive corrections necessary in the analysis of diffraction data. In the present work, evidence for the existence of ordering has been obtained by accurate determinations of the partial molar entropy of thallium, S^M_{Tl}.

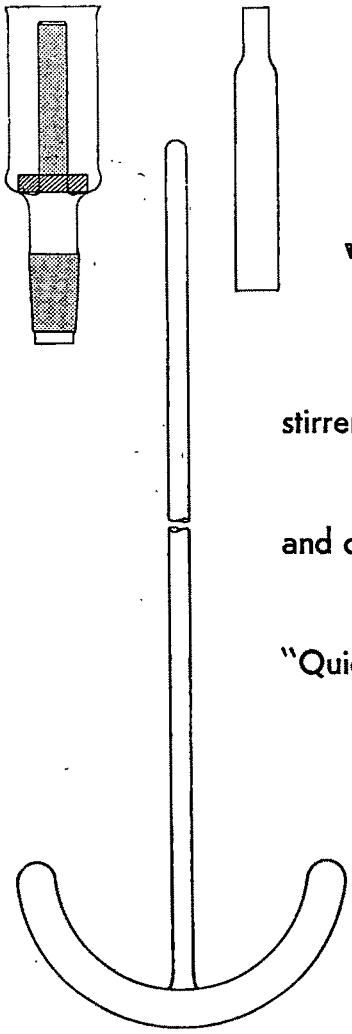
Measurements of electromotive force have been made on cells of the type:

$$Tl_{(cry.t.)}/TlSO_{4(aq.)}/Hg\text{–}Tl_{(liq.)}$$

between 10° and 90° C. for nine alloy compositions. The e.m.f.'s of all cells varied in the same general way with temperature, and the results with three representative alloys are shown in Fig. 1. Duplicate measurements on identical cells showed that the reproducibility over the range 20–35° C. was better than ± 0·02 mV. Confidence is felt in these results, as the calculated partial molar heats of solution of thallium agree to within 7 per cent with accepted direct calorimetric determinations[2,5].

The partial molar entropy of thallium, S^M_{Tl}, is calculated using the standard relation:

$$S^M_{Tl} = nF\left(\frac{\partial E}{\partial T}\right)_{N,P}$$



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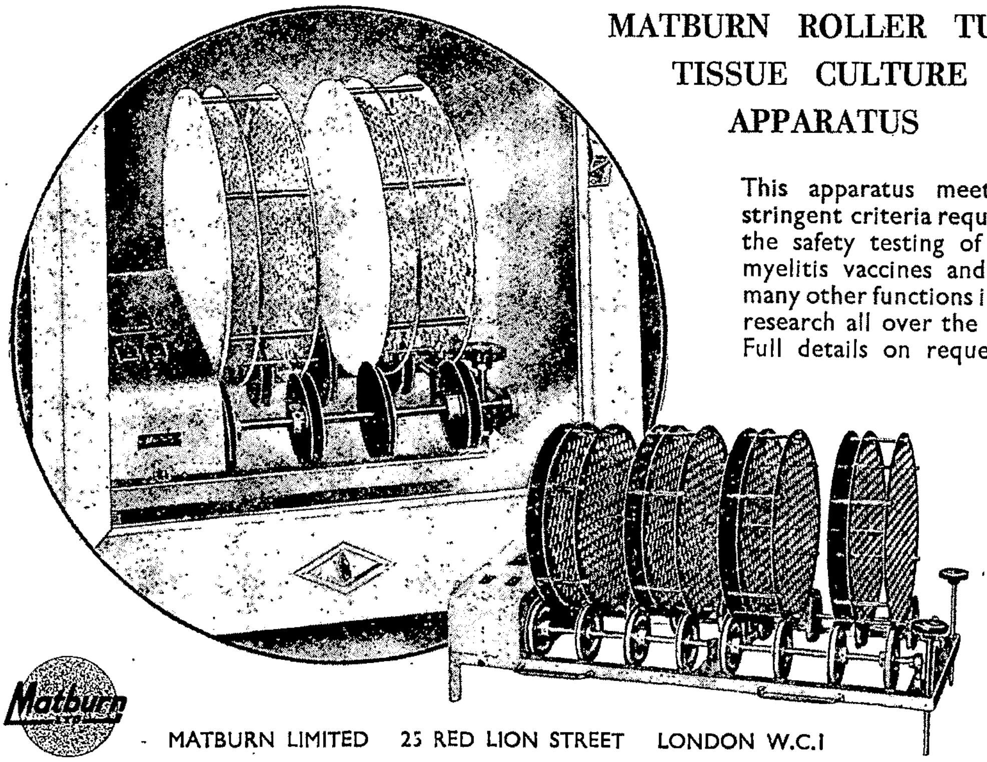

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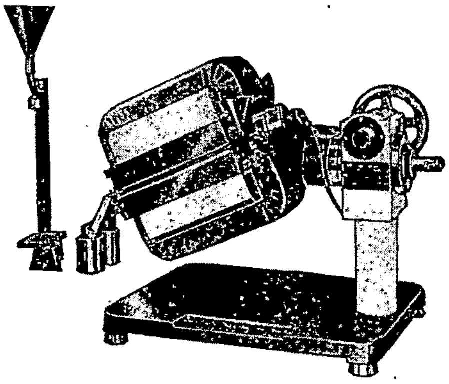

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and S^M_{Tl} for the range 20–35° C. is given in Fig. 2. The e.m.f. values above 50° C. were much less reproducible, and the error introduced into the S^M_{Tl} values in this range renders them valueless for the present purpose.

The variation of S^M_{Tl} with composition in the range 20–35° C., Fig. 2, is characteristic of solutions showing short-range order[3,4], and confirms the earlier inconclusive evidence for ordering from X-ray measurements[1]. This effect was not noticed by previous workers[5], who used more widely spaced compositions. For an ideal random solution this plot would be linear with gradient $-R$, but short-range ordering introduces a deviation to lower entropies at concentrations below the ordering composition, and a symmetrical swing to higher entropies at higher concentrations[3,4]. The 'cross-over' composition at 29·4 atomic per cent thallium indicates that ordering occurs at the composition $Hg_{12}Tl_5$; this formula could equally well be assigned to the solid-state compound for which Hg_5Tl_2 (28·6 atomic per cent thallium) was originally proposed, as both compositions fall within the limits of accuracy of the equilibrium phase determinations[6].

The change in entropy in the ordering region (27–32 atomic per cent thallium) is quite small (± 0·3 J.E.U.), indicating rather feeble ordering, which would account for the difficulty in detecting ordering in the diffraction studies[1]. The low heat of formation of the solid alloy[7] of − 0·35 kcal./gm.-atom also suggests a feeble tendency to compound formation.

The increasing gradient of the e.m.f. vs. temperature plots (Fig. 1) between 35° and 50° C. indicates an increase in the entropy of thallium which may reasonably be interpreted as an increase in atomic randomness over this temperature-range. This occurs at all alloy compositions, and approximate entropy values from the upper slopes of the curves indicate that complete randomness is not attained; it seems likely that the change is one of co-ordination. Accurate entropy values above 50° C. are necessary to clarify this position, and attempts are now being made to obtain stable reproducible e.m.f.'s between 50° and 90° C.

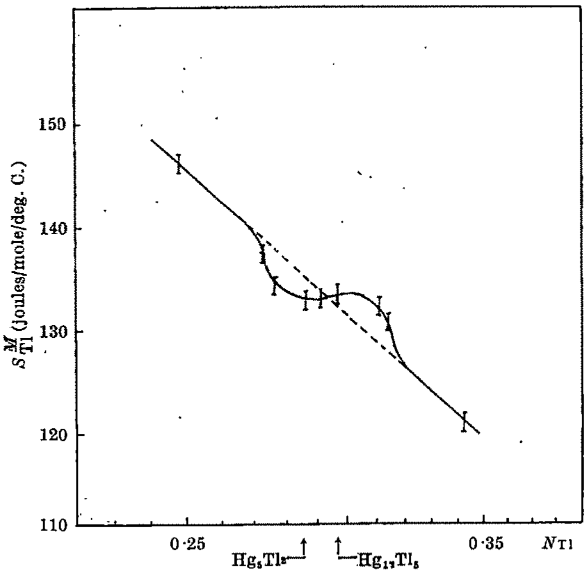

Fig. 2. Partial molar entropy of solution of thallium (S^M_{Tl}) vs. log composition (mole fraction thallium) at 20° C. The estimated errors in the experimental points are indicated

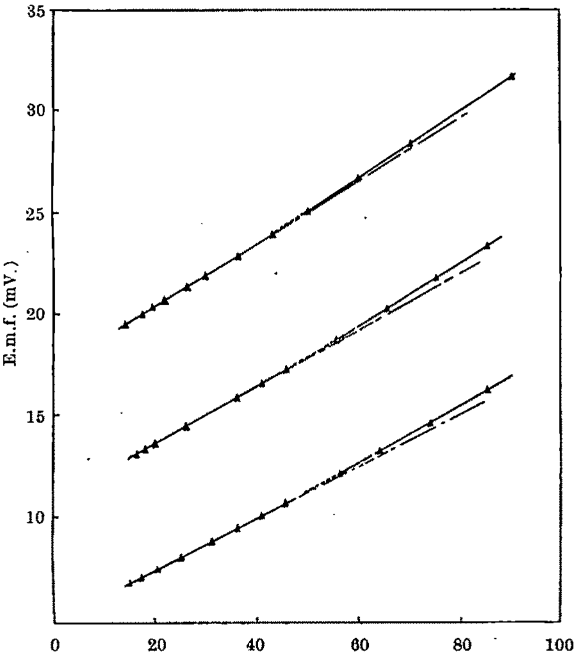

Fig. 1. Typical plots of e.m.f. (mV.) vs. temperature (° C.). Top, N_{Tl} = 0·2480; centre, N_{Tl} = 0·2917; bottom, N_{Tl} = 0·3437

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Low-Angle X-Ray Scattering by Glasses

THERE have been reports on the discovery of low-angle X-ray scattering by glasses, and evidence has also been presented to the contrary[1–4]. In trying to produce low-angle X-ray scattering by various types of glasses it became apparent to us that spurious effects might arise when using powder samples, owing to the surface scattering by the grains of the ground glass. This consideration also made us doubt the results of Hoffman and Statton[3].

In our further attempts to obtain low-angle X-ray scattering we used polished glass plates, about 0·2 mm. in thickness. Complete absence of any surface effects was ensured by varying the thickness of the samples. The X-ray exposure was carried out in an evacuated chamber with Kratky collimation[5]. Filtered copper K_α-radiation was used with a sample-to-film distance of 350 mm.

We succeeded in producing a clear and reproducible low-angle X-ray scattering pattern for a series of samples of glass containing 7 per cent of sodium oxide, 23 per cent of boron oxide (B_2O_3) and 70 per cent of silicon (in mole per cent) ('Vicor' glass) heated at 600° and 650° for various time intervals (1–8 hr.) and quenched in air (Fig. 1). The initial sample was annealed at 500°. The intensity of the scattered light was also measured and found to increase with temperature and duration of heat treatment. At the same time, we obtained low-angle X-ray scattering by porous glasses produced by leaching the same samples (dotted curves in Fig. 1). Calculation has shown that the radii of the inhomogeneities in the initial glasses and the pore radii in the leached samples are very nearly the same, varying from about 100 A. for an original sample to about 900 A. for a sample heated at 650° for 6 hr. The corresponding increase in the intensity of scattered light is greater than 1,000 times.

Thus we have direct evidence for a chemically inhomogeneous structure in certain sodium borosilicate glasses. This evidence is strengthened by the similar size of the inhomogeneities artificially produced in the same glasses by leaching. (Some discrepancies between the dotted and full lines in Fig. 1 for samples 5 and 6 may be explained in terms of different operating conditions for the X-ray tube during the exposure of the glasses mentioned, namely, 30 kV. for the original and 15 kV. for the porous glasses.)

The observed intensity of the low-angle X-ray scattering is very low. Indeed, whereas porous glasses require exposure times of the order of several minutes, many scores of hours are needed when examining the original glasses. The reason lies in a very small difference between the electron densities in the chemically inhomogeneous regions. For the glasses investigated, this difference, calculated from the electron density of vitreous silica and the ratio of X-ray intensities scattered by the original and the porous glasses, is only about 0·04 electron/A. This explains why the attempts at producing low-angle X-ray scattering by other types of glasses have failed. These would also have considerably smaller inhomogeneities (if there were any at all), which would greatly increase the exposure time required. For example, an exposure of more than 2,000 hr. would be required with our apparatus to produce scattering by the same 'Vicor' glass with an inhomogeneity size of 50 A. To reveal such small chemical inhomogeneities considerably more sensitive apparatus should be used.

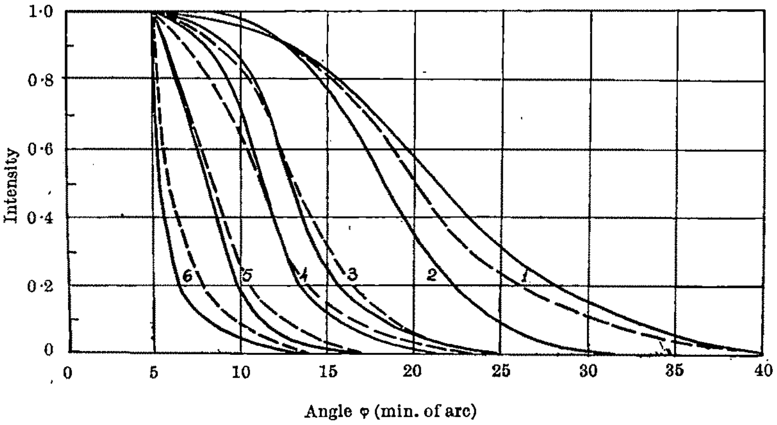

Fig. 1. Low-angle X-ray scattering intensity curves for original (——) and porous (– – –) glasses obtained by heat treatment of the original glasses as follows (relative intensities of light scattering are shown in brackets): 1, 500° (1); 2, 600° for 2 hr.; 3, 600° for 4 hr.; 4, 600° for 8 hr. (3·4); 5, 650° for 1 hr. (30); 6, 650° for 6 hr. (> 1,000)

A complete report of this work will be published in the Chemistry Section of *Transactions of the Academy of Sciences of the U.S.S.R.*

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Emission and Absorption Spectra of NCO and NCS

Several polyatomic free radical spectra have been observed in fluorescence when various compounds are irradiated with Schumann ultra-violet radiation. Neuimin and Terenin[1] observed the spectrum of NH_2 in emission with this technique, and Style and co-workers have reported several fluorescence spectra which they have assigned to HCO (ref. 2), HCOO (ref. 3), CH_3O (ref. 4) and C_2H_5O (ref. 4).

A few years ago, two of us (R. H. and D. W. G. S.) observed a series of bands in the region 4250–4650 A. in the fluorescence from ethyl *iso*cyanate (C_2H_5NCO). The bands were also observed in emission from a high-frequency discharge through this compound at a pressure of about 1 mm. mercury. A reproduction of the bands excited by this latter technique is given in Fig. 1*a*. The principal feature is a group of strong bands in the region of 4400 A. A similar, but much weaker, group lies 1,275 cm.$^{-1}$ to lower frequencies of the main group. With both methyl thiocyanate (CH_3SCN) and methyl *iso*thiocyanate a series of ten bands in the region 3750–4850 A., together with a few weaker and less widely spaced bands at shorter wave-lengths, were obtained as a fluorescence, as shown in Fig. 1*b* and *c*. These bands were also readily obtained from the discharge through methyl thiocyanate. The interval of about 700 cm.$^{-1}$ is prominent.

Although the dispersion was insufficient to resolve the rotational fine structure, the fact that identical fluorescences were given by thiocyanate and *iso*thiocyanate suggested that the NCS radical was the emitter of these bands, and that those given by ethyl *iso*cyanate were due to NCO.

Since the energy of the ultra-violet radiation used for excitation in the fluorescence experiments is limited to about 9 eV. by the transmission limit of the fluorite windows, and since this energy is used to dissociate the parent molecule and to produce one of the dissociation products in an excited state, it is clear that the lower state of the emitter can only be the ground-state or a very low lying excited state. In the former case it

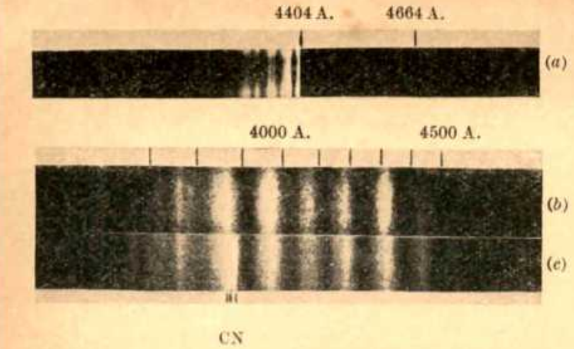

Fig. 1. Emission spectra of NCO and NCS. *a*, High-frequency discharge through C_2H_5NCO, glass spectrograph ; *b*, *c*, fluorescence from CH_3NCS and CH_3SCN, respectively, quartz spectrograph

should be possible to observe the spectrum in absorption.

Experiments were therefore carried out at Ottawa on the flash photolysis of the above compounds in an attempt to obtain these new spectra in absorption. The apparatus was similar to the one described earlier[5]. Four photolysis lamps were used, each being fired by a 33-μF. condenser charged to 7 kV. The reaction cell was 50 cm. long and multiple reflexion mirrors were used to increase the optical path-length to 10 m. The spectra were photographed using a 21-ft. concave grating spectrograph.

During the flash photolysis of ethyl *iso*cyanate at 5 mm. pressure several violet degraded bands were observed in absorption in the region 3600–4500 A. ; in addition, seven red degraded bands were observed between 2620 and 3160 A. The bands were observed with increased intensity during the flash photolysis of *iso*cyanic acid, HNCO. The strongest violet degraded absorption band is reproduced in Fig. 2*a* and corresponds to the strongest band observed in emission (Fig. 1*a*). A typical red degraded band is shown in Fig. 2*b*. A rotational and vibrational analysis of several of the violet degraded bands has been carried out and shows that the bands belong to a $^2\Sigma$—$^2\Pi_i(a)$ electronic transition of a linear molecule. The rotational constants are $B'_{000} = 0{\cdot}402_1$ cm.$^{-1}$ and $B''_{000} = 0{\cdot}389_4$ cm.$^{-1}$ and are consistent with the assignment of the carrier to the NCO radical. The red degraded bands belong to a second electronic transition which appears to be of the type $^2\Pi_i(a)$–$^2\Pi_i(a)$. The two band systems are thus analogous to the well-known band systems[6,7] of the isoelectronic molecule CO_2^+, except that the order of the excited states is reversed.

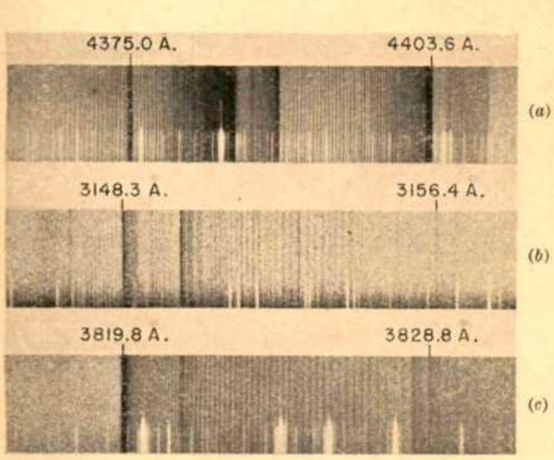

Fig. 2. Absorption bands of NCO and NCS photographed with a 21-ft. grating spectrograph during flash photolysis experiments : *a*, strongest band of the violet degraded system of NCO from HNCO ; *b*, a typical band of the red degraded system of NCO from HNCO ; *c*, a typical sub-band of NCS from CH_3SCN (diluted with argon)

Another series of red degraded bands was observed in the region 3350–4000 A. during the flash photolysis of methyl and ethyl thiocyanates and ethyl *iso*thiocyanate. Two of the bands with heads at 3712 and 3820 A. correspond to two of the emission bands shown in Figs. 1*b* and 1*c*. Under high resolution the rotational structures of these bands correspond to $^2\Pi_i(a)$–$^2\Pi(a)$ bands of a linear molecule with large sub-band spacings. One of these sub-bands is reproduced in Fig. 2*c*. The bands are similar to the corresponding bands of NCO and may be assigned to the NCS radical.

From the methods of production of these spectra and from the rotational fine structures of the bands there can be little doubt of the assignment of the spectra to the NCO and NCS free radicals. Detailed rotational and vibrational analyses are being carried out at Ottawa and will be published in due course.

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Cadmium Bromide : Growth Spirals and Possible Polytypism

IN recent years growth spirals have been observed on crystals of nearly thirty[1] substances. Detailed descriptions of these markings, as well as their relationship to screw dislocations, have been given especially of crystals of silicon carbide[1,2] and cadmium iodide[3]. I wish to report the occurrence of growth spirals on crystals of cadmium bromide ($CdBr_2$), and to comment on their implications regarding possible structural polytypism in this compound.

Numerous spiral markings have been observed on the (0001) faces of cadmium bromide crystals. These crystals, which measure approximately 0·2 mm. across, were grown from an aqueous solution of cadmium bromide, reagent grade ($CdBr_2.4H_2O$), to which a liberal amount of hydrobromic acid had been added. For the most part the markings are circular with a slight suggestion of hexagonal or triagonal shape. Both left- and right-handed spirals occur. Single spirals are present, but combinations and intergrowths of spirals are more common. Fig. 1*A* shows a marking produced by three screw dislocations of the same sign, sufficiently close together

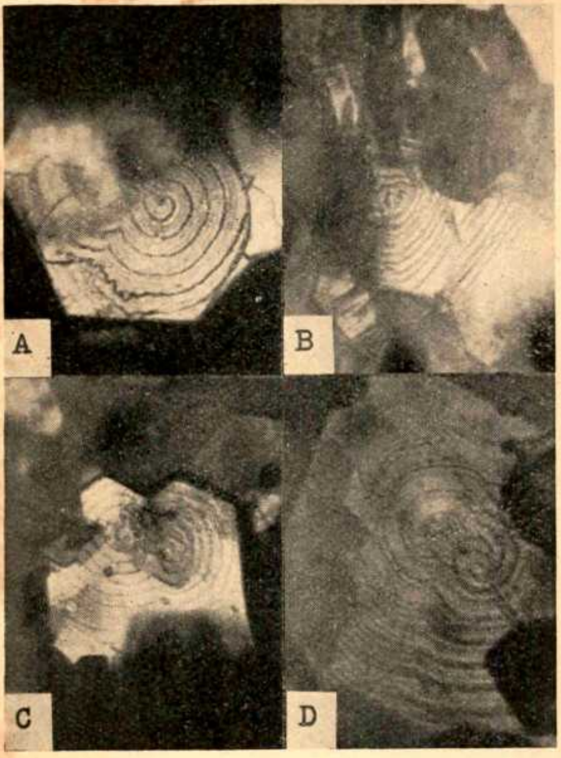

Fig. 1. Photomicrographs of growth spirals on crystals of cadmium bromide ($CdBr_2$). Vertically reflected light. (× 216)

for co-operation with one another. The Burgers vector of one of the dislocations is greater than the other two, thus producing the more prominent spiral step. More complicated patterns were seen in which the distance of separation of the dislocations was greater. Frequently one observes spirals formed from two or more dislocations of opposite sign. Fig. 1*B* shows a case where two dislocations of opposite sign, and of the same Burgers vector, have interacted to form closed triangular loops. Fig. 1*C* illustrates a case where two spirals of opposite sign and some distance apart interacted with each other. This looks like a case in which two crystals have joined and then grown. Many other more complicated cases were observed in which dislocations of the same and opposite signs and different Burgers vectors result in interacting spiral markings (Fig. 1*D*).

Recent studies have shown a relationship between structural polytypism and the spiral growth of crystals resulting from screw dislocations in silicon carbide[4] and cadmium iodide[5] structures. From a knowledge of these studies, I propose that a series of polytypic structures may also exist for cadmium bromide. Normal cadmium bromide, designated as $6R$ by Ramsdell's[6] notation, has an ideal structure represented by $[(A\gamma B)\ (C\beta A)\ (B\alpha C)]_n$, in which bromine ions are represented by Roman letters and cadmium ions by Greek letters in the common notation for the closest packing of spheres. The following structural series might be formed by various single dislocations in this ideal structure :

$2H$, $[(A\gamma B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)]_n$
$8H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)]_n$
$14H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)]_n$
$20H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)$
$(A\gamma B)]_n$, etc.

Using the Ramsdell zigzag sequence[6] of bromine ions in the $(11\bar{2}0)$ cross-section, the hexagonal series could be represented by (1,1), (7,1), (13,1), (19,1) . . . ($n6 + 1,1$), where n is either zero or an integer. From a study of the geometry of the structure of cadmium bromide I have also conceived the possibility of less common dislocations producing a second series of polytypes :

$4H$, $[(A\gamma B)(C\alpha B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)]_n$
$10H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\alpha B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)]_n$
$16H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\alpha B)]_n$
$6R$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)]_n$
$22H$, $[(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)(A\gamma B)(C\beta A)(B\alpha C)$
$(A\gamma B)(C\alpha B)]_n$, etc.

The zigzag sequence symbols for the hexagonal forms are : (2,2), (8,2), (14,2), (20,2) . . . ($n6 + 2,2$). In both these series the ideal structure $6R$ always results when the Burgers vector strength is a multiple of 6. Co-operating dislocations of mixed signs and Burgers vector strengths would, of course, generate other more complicated polytypic structures.

I am currently engaged in an X-ray study of this compound to ascertain if some of the predicted structures exist. I have verified the ideal structure and found the $4H$ form as well as strong evidence for other polytypes. In an earlier study, Pinsker[7] reported the existence of $2H$ and $4H$ forms. The results of the present X-ray study will be published in due course.

This work is being financed by a Research Corporation Frederick Gardner Cottrell grant.

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Vacuum Arcs on Tungsten Cathodes

IN the course of a programme of work on direct-current arc discharges at low gas pressure an interesting phenomenon was encountered.

Photomicrographs of tungsten cathode surfaces were taken before and after an arc of 150 amp. had operated for about 30 msec. in air at 1μ of mercury. The arc was initiated by touching a pointed anode on to the cathode surface. Both electrodes were of tungsten rod, as used for inert electrode welding. This material was later analysed spectroscopically and found to contain only trace impurities. The cathode surface shown in the illustrations was finished with grade 3–0 polishing paper.

Fig. 1*a* shows a ¼-in. diameter cathode, at a magnification of six times, before the arc occurred, and Figs. 1*b* and 2 show the same surface after arcing at magnifications of six and seven hundred respectively.

It can be seen that small areas of tungsten have been melted and the craters are distributed along fine cracks which were present before arcing.

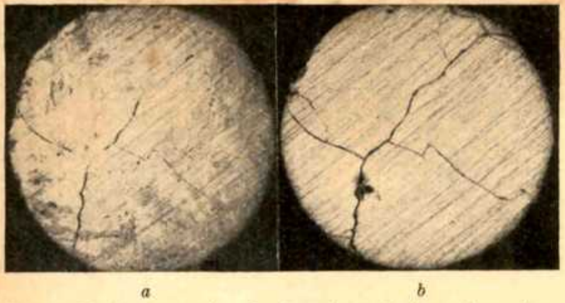

Fig. 1. Photomicrographs of a tungsten cathode surface. Arc current 150 amp., residual gas, air at 1μ mercury pressure, arc duration about 30 msec. *a*, Before arcing; *b*, after. (× 6.) The dark marking in the bottom left quadrant of *b* is the point of contact of the electrodes

Photomicrographs at high power (× 1,000) of the same section of the cathode surface, before and after arcing, show conclusively that melting occurs only on the cracks, when these exist. Results on specimens without cracks show isolated patches of overlapping craters, the surface in between appearing quite undisturbed—at least under visual observation at magnifications up to a thousand.

Other experiments, which will be reported in full elsewhere, indicate that vacuum arcs on both refractory and non-refractory cathodes behave like cold cathode arcs and have a small, mobile cathode spot region. Using a fine crack on a tungsten cathode to 'guide' the cathode spot, attempts were made to photograph this region using high-speed ciné photographic techniques. The experiments were unsuccessful. It is considered quite possible that the cathode spot does not move along the track at all, but has a random motion and only melts the tungsten when it crosses the sharp edge of a crack.

The melting is never continuous, although simultaneous oscillograms show the arc voltage to be continuous, though fluctuating.

The craters are very small in area, for example, some of those shown in Fig. 2 are about a micron in radius, giving an area of only about 3×10^{-8} cm.^{2}, Now, although the total arc current is 150 amp.. 'spot splitting' occurs, that is, there are many small cathode spots active, 'in parallel'. Thus the current associated with each crater is not known, but it is considered that it is at least 1 amp. and very probably more. Also, the actual area over which electron emission occurs may be greater than the melted area, but even when this is borne in mind, these results indicate an extremely high current density at the cathode. Values between 10^7 and 10^8 amp./cm.^{2} are by no means out of the question.

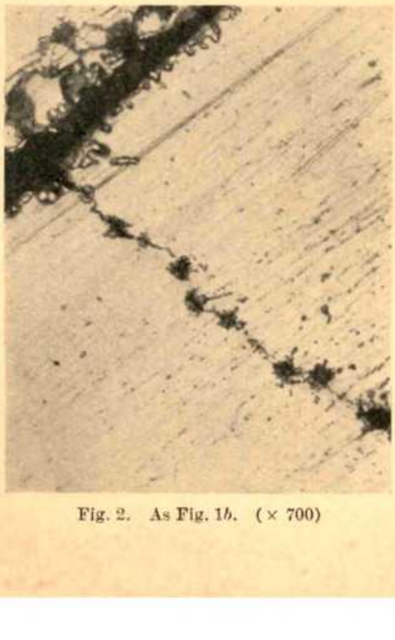

Fig. 2. As Fig. 1*b*. (× 700)

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Tensile Strength of Indium

THIS communication presents new approximate values of tensile strength and percentage elongation for indium.

Most tabulations[1,2] of properties list the following mechanical properties for indium containing 0·29 per cent impurities:

Tensile strength	7·99 tons/in.^{2} or 17,900 lb./in.^{2}
Percentage elongation in 3 in.	26·5 per cent

These data were taken from the work of W. Chandler Roberts-Austen[3] in which he studied the effect of adding small amounts of impurity metals on the tensile strength of gold. In his table of data[3] is listed the above-mentioned properties for an alloy of gold containing 0·29 per cent indium, which has since been misinterpreted as applying to indium with a 0·29 per cent impurity. Upon discovery of this error, we undertook an investigation of the true properties of indium.

We had obtained a limited amount of indium (99·97+ per cent pure) from the Indium Corporation of America in connexion with other studies. This was cast into three tensile bars using heated graphite moulds. The size and shape of the bar is not standard (see Fig. 1), but was assumed to be satisfactory for the test, since similar bars cast of lead produced results comparable to the accepted values for that metal.

Standard tensile test machines are unsuitable for testing material of such low strength. To overcome this difficulty, a method was devised consisting of gradually filling a bucket, suspended by the tensile bar, with lead shot. This method has two distinct advantages, namely, adaptability to low loads and control of loading rate. The latter is very important when one recalls that soft materials such as indium creep at room temperature.

The conditions and results of the tests were as follows:

Bar No.	Diameter (in.)	Gauge length (in.)	Area (in.^{2})	Load (lb.)	Elongation (in.)	Tensile strength (lb./sq.in.)	Percentage elongation
1	0·369	0·78	0·1070	42·25	1·32	395	69
2	0·371	0·78	0·1080	38·75	1·32	359	69
3	0·370	0·78	0·1075	44·13	1·34	410	72
					Averages	388	70

Fig. 2 shows the pulled bars. A loading rate of 8·6 lb./min. was used in all tests. The average tensile strength of indium is approximately 388 lb./in.^{2} and the average elongation is approximately 70 per cent. Fig. 3 shows the nature of the fracture in the three bars (they are numbered from left to right as in Figs. 1 and 2). Bar No. 3, which had the highest values of tensile strength and elongation also has the expected type of fracture, showing almost 100 per cent reduction in area. This tends to indicate that the averages of 388 lb./in.^{2} and 70 per cent are on the

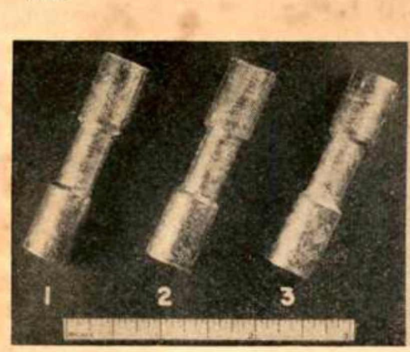

Fig. 1. Tensile bars as cast

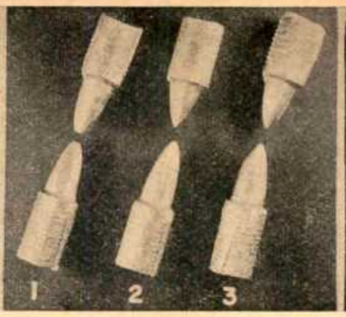

Fig. 2. Tensile bars after fracture

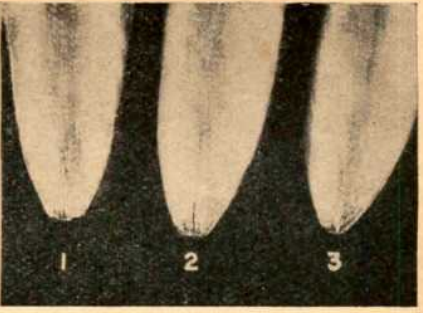

Fig. 3. Appearance of fractures

low side, probably due to imperfections in the cast bars.

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Mass Spectrometry of Substances of Low Volatility

A LARGE range of substances which, because of their thermal instability or involatility, are unsuitable for admission in the gaseous state through a heated-inlet system into the ionization chamber of a mass spectrometer are usually studied by means of devices for volatilizing them very near the ionizing beam[1-6]. As a variant of the technique described by Bradt and Mohler[5], a Metropolitan-Vickers *M.S.*3 tube has been modified for the study of the effects of heat on coal and coal extracts in the temperature range 60–450° C.

The replacement of the original ion-source flange by one with additional electrical leads and an enlarged gas-inlet tube has made it possible to mount an electrically heated tubular furnace within 1 cm. of the entrance-port of the ionization chamber. The main differences from the apparatus of Bradt and Mohler are the following: (*a*) since the furnace has a heat capacity which is large compared with the sample holder, the thermocouple has been mounted in the furnace block; (*b*) the sample holder is mounted at the end of a glass rod extending up the gas-inlet tube in order that the whole unit may be moved in and out of the furnace magnetically by means of an iron bar sealed in the opposite end of the holder, thereby permitting out-gassing of the furnace, adjustments of temperature, and determinations of blanks; (*c*) the gas-inlet system remains connected to permit the introduction of mass-markers or to check the performance of the instrument under standard conditions.

The most satisfactory design of sample holder has been made from about 0·15 gm. of fine copper gauze rolled to form a cylinder which makes a good sliding fit inside the furnace tube. This is held on the probe by a small chuck, which also reduces the streaming of products back into the upper portion of the tube.

The normal procedure has been to study the growth and decay of the spectra at a succession of increasing temperatures. With the present vibrating reed electrometer and Sunvic *RSP*2 recorder (1 sec. full-scale deflexion) a scan of the mass region 53–215 can be made with reasonable accuracy in 6 min. This period is short compared with the life-time of the spectra produced by samples of 1–10 mgm. The amount of an individual substance released can be evaluated by time-integration of the height of a characteristic mass-peak because of the simple relation which exists between this integral and the sensitivity and leak-rate measured for the conventional inlet system.

Polystyrene was found to be a suitable material for testing the installation, and, as in the work of Bradt, Dibeler and Mohler[4], the monomer, dimer, trimer and tetramer were detected among the degradation products. For samples from different sources (for example, a commercial, catalyst-initiated polymer, a purified thermally initiated laboratory polymer, and an isotactic polymer) an interesting variation in behaviour has been observed with respect to the relatively small amount of decomposition which occurs in the temperature range 160–280° C. The details of a brief investigation of this phenomenon will be reported shortly.

A selection of coal vitrains is being studied by this technique. In addition to loosely bound aliphatic material with a wide range of molecular weight, a group of alkyl-substituted benzenes, naphthalenes and higher aromatics have been observed between 200° and 370° C. Above this temperature, where first traces of decomposition are signalled by the appearance of methane, corresponding series of substituted phenols and naphthols have been detected.

The instrument is also being used to characterize coal extracts and to estimate the distributions of molecular weights in various vacuum-distillation fractions.

Our thanks are due to the National Coal Board for the financial support of this investigation, further details of which will be published shortly.

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June 13.

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APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

University Demonstrator (with an honours degree in chemistry or agricultural chemistry, and preferably a special interest in the problems of soil fertility) in Soil Science, for duties which will involve demonstrating in the whole field of soil science—The Secretary, School of Agriculture, The University, Cambridge (August 6).

Assistant in Zoology—The Secretary of the University Court, The University, Glasgow (August 8).

Laboratory Steward (over 21, previous experience in a biological, medical, biochemical or chemical laboratory, and preferably experience in the preparation of biological materials and photography) in the Department of Botany—The Registrar, University College, Singleton Park, Swansea (August 8).

Assistant Lecturer, Grade B, in Telecommunications and Electronics—The Clerk to the Governors, Woolwich Polytechnic, London, S.E.18 (August 9).

Assistant Lecturer in Inorganic and Structural Chemistry, and an Assistant Lecturer in Organic Chemistry—The Registrar, The University, Leeds 2 (August 9).

Lecturer in Physics, and a Lecturer in Bacteriology at the University of Adelaide, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 13).

Senior Lecturer or Lecturer (with a good honours degree and teaching experience) in Physics at the Nigerian College of Arts, Science and Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 15).

Assistant Lecturer or Lecturer (preferably with some experience of structural analysis of organic and biomolecular compounds, and of the use of electronic digital machines) in Physics, with special reference to X-ray crystallography—The Secretary, Birkbeck College, Malet Street, London, W.C.1 (August 23).

Guinness Lecturer in Biochemical Engineering, to work in the Ramsay Memorial Laboratory of Chemical Engineering—The Secretary, University College, Gower Street, London, W.C.1 (September 1).

Assistant Lecturer in the Department of Geography—The Registrar, The University, Liverpool (September 6).

Reader in Fluid Mechanics at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (September 11).

Associate Professor (with postgraduate experience of veterinary anatomy) of Veterinary Anatomy at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 15).

Reader, Senior Fellow or Fellow in the Department of Astronomy (Mount Stromlo Observatory), Research School of Physical Sciences, Australian National University, Canberra—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 15).

Senior Research Associate in Upper Atmospheric Physics, to carry out experimental and observational research on the airglow and auroræ—Prof. D. R. Bates, F.R.S., Department of Applied Mathematics, The Queen's University, Belfast (September 20).

Lecturer in Physiology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 22).

Assistant Lecturer in Botany—The Registrar, The University, Manchester (September 30).

Lecturer (with a degree in veterinary science or in science with honours in comparative anatomy) in Veterinary Anatomy at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Lecturers (2) (with an honours degree in civil engineering and preferably with research or teaching experience in either hydraulics or soil mechanics) in Civil Engineering at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Lecturer or Senior Lecturer in Mathematics, and a Lecturer in Mathematics at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 13).

Senior Research Officer or Research Officer (male, qualified zoologist with experience of fisheries research) in the Fisheries Research Unit, Department of Zoology, University of Hong Kong, The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 30).

Chair of Organic Chemistry in the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Assistant Lecturer (with a degree or diploma in horticulture) in Horticulture—The Registrar, Massey Agricultural College (University of New Zealand), Palmerston North, New Zealand.

Assistant Technical Editor (preferably between 20 and 30, with at least a pass degree in science, technology or arts) with the Ministry of Power in Sheffield, for work on reports and papers concerning safety in mines research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.266/8A.

Biochemical Technician in the Physiology Department of the Medical School, to take charge of the preparation of material for biochemical classes for medical, dental and science students, and to assist if required in research work of a biochemical nature—Prof. A. A. Harper, Department of Physiology, Medical School, King's College (University of Durham), Newcastle-upon-Tyne 1.

Biochemist, Senior Scientific Officer or Scientific Officer grade (with considerable experience in the field of protein chemistry and/or tissue metabolism) in the Physiology Department, to take part in a programme of research on the biosynthesis of protein in the mammary gland—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks quoting Ref. 58/14.

Biochemist (with a degree in biochemistry, and preferably a Ph.D.), for full-time research on biological oxidation under Dr. V. Massey—The Secretary, Department of Biochemistry, The University, Sheffield 10.

Botanist (with a good honours degree and preferably some research experience, particularly in plant physiology), to join a small team engaged on studies of the constituents of natural rubber latex—The Director of Research, British Rubber Producers' Research Association, 48–56 Tewin Road, Welwyn Garden City, Herts.

Fish Biologist (with a good honours degree in natural science (zoology) and at least two years suitable postgraduate training or experience) at the Fish Culture Research Station, Malacca, Federation of Malaya, to study breeding, growth, feeding habits and life-history of fish of importance to fish culture—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/23/04.

Inorganic or Physical Chemists, Assistant Experimental Officer grade, at the Water Pollution Research Laboratory (D.S.I.R.), Stevenage, Herts, for work on physico-chemical problems in the study and prevention of pollution of rivers—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. F.479/8A.

Laboratory Technician (preferably with chemistry or physics experience equivalent to G.C.E. "A" level), for specialized work—The Secretary, Wright-Fleming Institute, St. Mary's Hospital, Paddington, London, W.2.

Lecturer (with a suitable degree and industrial or research experience, and preferably an interest in one of the following items: applications of X-ray crystallography, isotopes, statistics or fatigue) in the Department of Industrial Metallurgy—The Deputy Registrar, The University, Birmingham 15.

Postdoctoral Fellow in Inorganic or Organic Chemistry—The Chairman, Department of Chemistry, McGill University, Montreal, Canada.

Professors, Assistant Professors and Lecturers in Physics, Mathematics, Chemistry, Botany and Zoology at the University of Baghdad, Iraq—The Cultural Attaché, Embassy of the Arab Union, 22 Queen's Gate, London, S.W.7, or direct to Secretary-General, University of Baghdad, Iraq.

Research Scholars (with a first- or second-class honours degree, or the G.R.I.C.) in Chemistry, for work on the mechanisms of organic reactions and on organometallic compounds—The Registrar, The University, Leicester.

Scientific Officer or Senior Scientific Officer (with an honours degree and/or higher degree, and preferably a good knowledge of livestock and milk production), to develop current work on mastitis in relation to management—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, quoting Ref. 58/20.

Senior Scientific Officer or Scientific Officer (with a first- or second-class honours degree or equivalent, several years experience in electronics or communications, and preferably also in airborne equipment design and pulse techniques), for duty at Orfordness, Suffolk, as a senior member of a team responsible for the design of air-borne telemetry equipment and associated ground stations, the organization and carrying out of flying trials on various types of weapons, and the analysis and evaluation of the results—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. 1845/34.

Student Technicians in the Department of Bacteriology and Pathological Museum—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

REPORTS and other PUBLICATIONS

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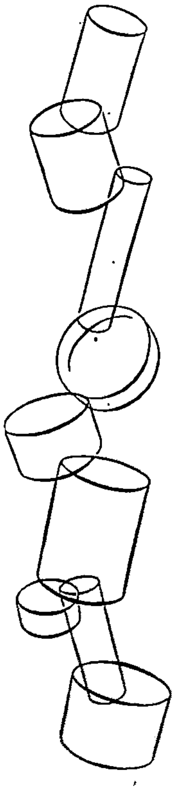

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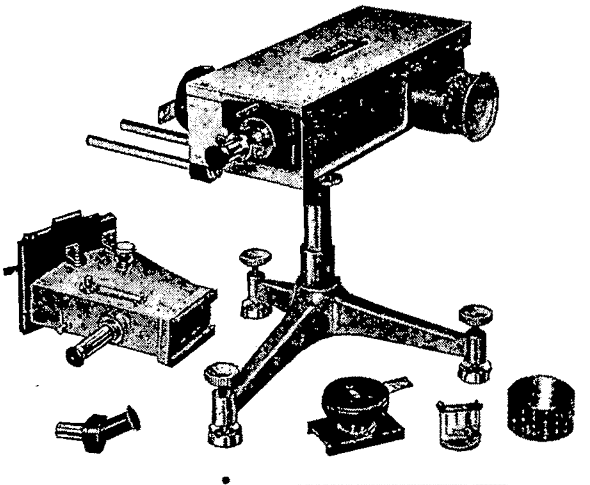

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NUCLEAR ENERGY DEVELOPMENT AS A PROBLEM OF MAN-POWER

THE White Paper on "Capital Investment in the Coal, Gas and Electricity Industries"* which was presented to Parliament in April gave the latest information about investment in 1957 together with the approved expenditure for 1958–59. It thus provides something of the background against which to consider the changes in the nuclear power position in Britain since announced, and to which the development of Euratom and particularly the provision of help from the United States have given added interest. Of the approved capital expenditure of £440 million in 1957 compared with an actual £390 million in 1956, £233 million and £206 million, respectively, were on account of the Central Electricity Authority, with a further £20 million and £17 million for the South of Scotland Electricity Board and £21 million and £20 million for the North of Scotland Hydro-Electricity Board. For 1958, out of £436 million approved, the corresponding figures are £239 million, £26·5 million and £17 million, respectively. Of this latter expenditure, no more than some £45·5 million is accounted for by nuclear power stations (including £8·5 million at Hunterston), although in England and Wales estimated expenditure on nuclear stations in 1957–58 was £21 million compared with £37 million approved for 1958–59 and represented continuing work at Bradwell and Berkeley and the commencement of work at Hinkley Point.

As already announced, the White Paper points out that work on new power stations is to be spread over the next 26 instead of 24 months, and the completion of the nuclear power programme is to be postponed for a year, while a higher proportion of the total new generating capacity will be in the form of coal-fired stations at lower capital cost. The decision of the Ministry of Defence that some of the nuclear power stations should be modified to produce plutonium of weapons grade represents, however, a much more considerable modification of the programme. The Paymaster-General, Mr. R. Maudling, explained in the House of Commons on June 24 that the modifications proposed at Hinkley Point and the next two stations in the programme of the Central Electricity Generating Board would not impair the efficiency of the stations and that the initial capital cost and any additional operating costs that may be incurred would be borne by the Government. On June 30 Sir Ian Horobin said in Parliament that the capital cost of the modifications was unlikely to exceed 1 per cent of the cost of the stations concerned and that building progress would not be affected.

While, therefore, the price of electricity may not be affected and the country may in fact be provided at comparatively small cost with a valuable insurance against possible future defence needs, this statement scarcely represents the full implications of this change in design. To obtain plutonium suitable for military purposes, the fuel rods must be renewed at intervals of months rather than of years, and the gross costs will undoubtedly be altered for the worse if fuel costing £10 million or more may all be removed by the end of the year instead of remaining in the reactor for five years. Apart from this, there will be the loss of experience in the probable life of fuel elements; and the processing plants of the Atomic Energy Authority, particularly the diffusion plant at Capenhurst and the chemical treatment plant at Windscale, are likely to be so overloaded that further capital investment by the Authority seems inevitable.

The cost of installing discharging mechanisms and cooling ponds of greater capacity is unlikely to be high, but diffusion plant and chemical treatment plant may be another matter. Serious interference with the nuclear power programme will arise because the plutonium is diverted to military purposes instead of being used to convert infertile material into nuclear fuels. To that extent more uranium will have to be mined and processed, and purchased; and some of the capital on which later reductions in the cost of electricity might be based will in effect be used for that purpose. Moreover, apart from the loss of experience already noted, it is possible that in the immediate future a shortage of plutonium for experimental purposes could retard technical innovations.

Nor is this the whole price to be paid. The rigorous distinction which Britain has hitherto made between its nuclear power programme now disappears, and the dual character of nuclear power stations is, on the contrary, emphasized. This has diplomatic as well as economic drawbacks, and no convincing reasons have yet been given to show that, on balance, the necessary supplies of plutonium would not have been obtained more advantageously by building a new reactor, or by more urgent efforts to utilize the over-abundant stocks built up in the United States—an attempt that the agreement on the exchange of nuclear weapon information signed in Washington on July 3 should facilitate, for it provides specifically for the supply of enriched uranium to the Atomic Energy Authority in Britain.

The change in policy will do nothing to remove the difficulties which it is believed in some quarters that the nuclear power industry is facing. Mr. A. L. G. Lindley, managing director of the General Electric Co., Ltd., expressed the view earlier in the year that no more than six additional orders for nuclear power stations would be placed by the Central Electricity Generating Board in the three years from 1959 compared with the dozen or more additional stations mentioned last year; nor did he expect much profit would accrue to British firms from the export of nuclear power stations, even though many nuclear power stations might be built to British design abroad. On the technical side, too, there is some evidence that builders of nuclear power stations have entered a period of diminishing returns from expenditure on research and development. Sir Christopher Hinton has confirmed this in warning the industry to avoid the difficulties of structure which beset the aircraft industry. From the end of this year, he said, the Board would be placing orders for two main conventional power stations and two nuclear power stations compared with the ten or more power stations ordered every year since the War, the reason being the high capacity of plant which would now be built in a single unit. He thought, too, that within his life-time the future of nuclear power in Britain would be based on developments of the Calder Hall reactor, and he did not expect fusion power of the kind which ZETA may tap to become important industrially for thirty-five or forty years.

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* Capital Investment in the Coal, Gas and Electricity Industries. Pp. 8. (Cmnd. 415.) (London: H.M. Stationery Office, 1958.) 6*d*. net.

The overdue agreement on the exchange of nuclear information between Great Britain and the United States may prove the latter forecast too pessimistic, for the freer the interchange of information in projects of this type the less likely is progress to be retarded by lack of contact or faulty judgment. Frank and free and informal discussion with other scientists and technologists is the best stimulant of the critical judgment and creative thinking which lie at the root of technological and scientific advance. It should be noted that in replying on an adjournment debate in the House of Commons on March 20, the Parliamentary Secretary to the Ministry of Power, Sir Ian Horobin, was confident that restrictions had not stunted our scientific effort in this field and that we had found happy and practical relations between the Atomic Energy Authority and industry. Whether or not Sir John Cockcroft is right in believing that there is no military use for thermonuclear fusion, scientists should make sure that the utmost use is made of the agreement resulting from the doctrine of interdependence which the Prime Minister and President Eisenhower proclaimed jointly last autumn.

The change in policy may bear equally on Britain's relations with Euratom. Even before the announcement on June 28 that Euratom was to receive massive financial and technical help from the United States, the Government had been for some time closely questioned in Parliament regarding British relations with Euratom. Like other member countries of the Organization for European Economic Co-operation, Great Britain is a member of the European Nuclear Energy Agency, the statute for which was published in a White Paper last February; this provides for close collaboration with Euratom, the members of which are also members of the Agency. On May 22 Mr. R. A. Butler told the House of Commons that the Prime Minister had suggested to the President of the Euratom Commission that, until Euratom had selected its permanent headquarters, the head of the United Kingdom delegation to the High Authority of the Coal and Steel Community should also be accredited to the Euratom Commission. He had also proposed that we should negotiate an agreement for technical collaboration, providing the framework for co-operation between the British Government and Euratom, to facilitate co-operation both between individuals and between individual industrial concerns, and complementary to the general co-operation on nuclear affairs in Western Europe as a whole through the European Nuclear Energy Agency.

Mr. Butler said that these proposals had been welcomed by Euratom, but on June 17 the Prime Minister could only add that preliminary discussion on this technical collaboration agreement were starting that week. On July 1 the Prime Minister said in Parliament that nuclear power plants were unlikely to be bought by the European Atomic Energy Community itself, but rather by individual undertakings in member countries. A number of such inquiries had been received by United Kingdom manufacturers and a letter of intent had been signed between an Italian undertaking and a United Kingdom group. The Government hoped to conclude agreements with the Community and, as appropriate, with member Governments, to provide the framework within which such exports could take place, and such an agreement was already in force with the Italian Government.

Mr. Macmillan pointed out that the supply of United Kingdom reactors, which were fully developed and available on ordinary commercial terms, was governed by very different circumstances from those which led to the United States–Euratom agreement. The latter agreement provides the framework for the joint construction of prototype reactors of American design which are still in the development stage. Under it, the United States will assist Euratom in a ten-year programme of reactor research and development for which 100 million dollars will be provided in the first five years to build five or six nuclear power stations for commissioning in 1963. These stations, which are likely to be of the pressurized-water reactor type, will have a total generating capacity of about 5 million kilowatts, and for the construction, estimated at 350 million dollars, about 135 million dollars will be provided as long-term United States credits to Euratom. The United States will also provide enriched uranium for these plants at prices regarded by the West as 'give-away' prices, and the United States Atomic Energy Commission will guarantee for twenty years the endurance of the fuel elements under the agreement.

The contribution to the fuel economy of the six Euratom countries will not be important for its own sake, but the construction and operation of the reactors will allow the establishment of a cadre of nuclear technologists essential for larger developments. The agreement may also assist in the development of nuclear technology in the United States by expanding the opportunities for prototype trials; but there is nothing in this to be interpreted as a blow to British prestige or to offset the very definite advantages which Britain possesses. It would be wrong, as Sir Claude Gibb has emphasized, to over-stress the opportunities which export trade in nuclear power offers to Britain. In his view, the main assets which Britain has to offer to highly industrialized countries are her experience in design detail, in construction and in operation, and these hold potentialities for the reduction of initial capital costs which the Euratom countries are unlikely to overlook.

Friendly contacts have already been established in London with Euratom representatives, and the very great possibilities of the reactor chosen by Britain will certainly be recognized. It can be built, for example, by quite modest extension of conventional engineering techniques, and offers good prospects of decreased capital costs. The use of natural uranium is a further advantage, for in view of the distribution of uranium, most countries employing this type of reactor could look forward to becoming self-supporting in fuel supplies.

Power stations of this design thus can, and probably will, be sold in Europe while the American construction programme gets under way; and there is no reason for being pessimistic about the future of developments in Europe because of the Euratom agreement with the United States, provided due regard is had, first to our relations with Euratom, and secondly, but no less important, to the magnitude of the British nuclear power programme in relation to the other demands on our limited resources. Mr. Macmillan's statement indicates the Government now realizes the importance of establishing our relations with Euratom on a proper footing, and that something more than a research link is needed; but whether the Government appreciates the significance of the second point is still rather doubtful.

The reply to a question in the House of Commons on July 1 disclosed that the survey of expenditure on research and development made in 1955 is still being examined, and no plans have yet been made for a further survey. Yet, to take one point alone, the demand on Britain's scientific and technical man-power, as well as on material resources, should have been one factor to be considered in determining how best to meet our need for plutonium, if not the magnitude of those needs. Sir Claude Gibb recently estimated that the British nuclear industry is already employing 10,000 engineers and scientists on research and development, and said that the effort to prepare tenders for one of the first 300-MW. nuclear power stations in Britain approaches 1,000 man-years—the figure which Sir Edwin Plowden has given for initial research and development after the completion of basic research study of feasibility. Considering his further estimates that, for one year's study of feasibility and an experimental reactor, fifteen to a hundred scientists or engineers may be required, 100–150 engineers for a year's work on reactor design, a staff of 200 for a two-year study of the reactor and 100 for the three years to build a prototype reactor and control experiments with the reactor, and that, including the necessary support facilities, each professional scientist or engineer employed costs the Atomic Energy Authority about £10,000, the magnitude of the effort required from the limited scientific and engineering man-power of Britain becomes apparent.

This effort by the Atomic Energy Authority—and its further part in training technologists—has to be added to the 10,000 employed already in nuclear work by industry, and to the effort in nuclear research which the universities are also making, and to which the Department of Industrial and Scientific Research makes significant grants. Doubts may well be felt as to how far Britain is able to support an export programme in nuclear power; but there can be none as to urgency of the task of expanding our resources in scientific, technological and technical man-power. The over-riding message of the White Paper on capital investment in the coal, gas and electrical industries, however, is the vital and urgent need for as accurate assessment as possible not simply of the demands which nuclear power is making on capital and other material resources but of its demands on the scientific and technical man-power of Britain and its relation to the magnitude and distribution of our effort in research and development generally. Only when the magnitude of nuclear power development is seen in proportion to the national effort and resources generally can it be judged whether the balance is sound and how far further development is prudent.

NEW IDEAS ABOUT MUSCLES

Bioenergetics

By Albert Szent-Györgyi. Pp. x+143. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 4.50 dollars.

"THERE is but one safe way to avoid mistakes—to do nothing—or at least to avoid doing something new. This, however, may be the greatest mistake of all." With these characteristic words Szent-Györgyi prefaces his book on bioenergetics. If his scientific readers expect to get from his book a precise report on ascertained facts they will be disappointed. Szent-Györgyi's work has throughout been marked by its bold advances, by its intuitions which, seeming rash at the time, are afterwards found to be verified.

In the field of muscle physiology, which still remains his chief centre of interest, if anyone so exuberant can be limited to one centre, his speculations and experiments of twenty years ago on actin and myosin were first of all regarded as fantasies but have now become the cornerstone of muscle biochemistry. Anyone who disregards Szent-Györgyi's intuitions takes a very big risk—they may turn out to be true. In this book he is speculating about one of the aspects of living structure which has usually fallen by the way, but which is essentially the main one of all. The problem is, in his own words, "How does energy drive life?"; "How does it move the living machine?" It is this problem, first in relation to muscle contraction and later on in the book related to many aspects of living performances, that Szent-Györgyi has his new suggestions to make. It is essentially an attempt to weld together ideas on physiological actions, on quantum relations, particularly with regard to excited states, especially the triplet state, and to examine the action of the chief magician of biological systems, adenosine triphosphate and its so-called energy-rich phosphate bond. It is true that the richness of the bond has been somewhat deflated in recent years, but it still remains a most remarkable fact that nearly all the energy changes that have been carefully studied in living systems operate through the making or breaking of such bonds and it is usually in connexion with adenosine triphosphate or very similar substances. It was Szent-Györgyi himself, refining the work of Needham and Engelhardt, who showed that the contraction of muscle is, as he says, "essentially the interaction of acteomyosin with ATP and ion". Most other biochemists would say it is associated with, or connected with this interaction, but Szent-Györgyi scorns any such qualifications.

He produces in his first chapter a picture of muscle contraction based on the rearrangement, inside an elongated myosin molecule, of the far smaller globular proteo-myosin molecules of molecular weight 4,500. Such reorganization has, however, still to be demonstrated. It seems more and more unlikely in view of the detailed picture presented by the electron microscope in the hands of Huxley and others. Indeed, any mechanism of muscle contraction involving the chain-length of a particular filament is probably inadequate. However, this does not effect Szent-Györgyi's subsequent argument, which is mostly concerned with how the energy needed for contraction gets into the muscle filament. Essentially, Szent-Györgyi's hypothesis can be written in his terms in the formula:

$$\xleftarrow{\qquad} \text{muscle activity, luminescence}$$
$$E_n \ldots \rightleftarrows E_3 \rightleftarrows E_2 \rightleftarrows E_1 \rightleftarrows E^* \rightleftarrows h\nu \text{ or } w$$
$$\xrightarrow{\qquad} \text{photosynthesis}$$

where E_n represents the energy reserve of the system and $h\nu$ or w, as the case may be, the light or mechanical work absorbed or given out. The characteristic feature on which he lays stress is the term marked E^* interposed between the last energy state and the final quantum product. This is the excited molecular stage. Szent-Györgyi here postulates the need for a special molecular configuration to allow this energy to travel from one part of the molecule to the other. These considerations lead him into a study of the photo-emission and photo-absorption of molecular systems, with the phenomena of fluorescence, phosphorescence and quenching. The intermediate states of the electronic excitation system can pass, exceptionally, through triplet forms, and these triplet forms of excitation he treats rather in the same way as the free radicals. As in the case of free radicals he imagines them to be immobilized in suitable states, particularly the glassy state. He equates the energy of the energy-rich phosphate bond, taken as 10 kcal., as corresponding to a wave-length of 2–3μ in the near infra-red. Modern measurements give it as nearer 6 kcal. and therefore in the range of 5–6μ, even farther in the infra-red. However, he does not expect these bonds to be stimulated directly by visible light, which has a far higher energy, but only through some intermediate mechanism.

So far Szent-Györgyi has followed fairly straightforward quantum chemical lines. He breaks new ground, however, by associating the conditions of triplet excitations and energy-transfer with the properties of water or, more particularly, of ice. He describes a series of beautiful qualitative experiments by which the fluorescence of certain dyes and certain biologically active substances has profoundly altered the freezing of the water in which they are dissolved. Ordinary freezing is less effective than sudden deep freezing in 'dry ice'. As, however, he carefully states that these effects are spoilt by substances such as glycerol, which prevent ice crystallizing, it is difficult to see that he is doing anything other than studying the reactions of such molecules expelled from the solution on the formation of ice crystals. It may be, however, that they are actually incorporated in the ice-crystal structure, but this would require more proof than he provides.

As he says himself, "when considering water structures we enter fantastic and fascinating worlds". It is certain that the experiments described here deserve to be taken up again under controlled conditions to find out what produces the large effects that he has observed. In any event, they are worth while in directing attention to the states of aggregation of water in biological systems, especially at low temperatures, of which the remarkable work of Dr. B. J. Luyet has shown the degree of complexity. Szent-Györgyi himself now tends to turn to water to explain a number of phenomena where previously attention had been devoted to the more purely biological structures such as myosin, particularly the role of bound water on the surface of protein and other intracellular micelles.

Szent-Györgyi heads the second part of his work on biological structures and functions with the remark, "Research is to see what everybody has seen and to think what nobody has thought". Earlier he says: "The more we learn about myosin the less we understand it, which suggests we are looking at it in the wrong way". In this section he turns to the structure of the water outside the muscle, which after all makes up more than 80 per cent of its weight, to set the picture to rights. He uses this concept not so much to explain the contraction of muscle but, in his characteristically upside down way, to explain the relaxation of muscle. As he says, "the problem of contraction is not what makes the particle shorten but what keeps them extended when at rest, or stretches them out again after contraction". This he explains by a kind of crystallization of the water in the immediate contact with myosin particles.

There follows a discursive but most suggestive account which links this with the action of adenosine triphosphate in other systems, and much complex biochemistry concerned with the various types of interference with energy transfers, for example, that produced by 2 : 4 dinitronaphthol or by iodine. There is no space here to go into the whole of the numerous fascinating suggestions he makes covering the whole range of biochemical and physiological phenomena. For example, he discusses the action of the drug chlorpromazine in the treatment of schizophrenia, provides an explanation of myotonia in relation to the action of the drug 2 : 4 dichlorphenoxy acetic acid which artificially produces the same symptoms, and in general discusses the whole question of health and disease right down to "oxidation, fermentation and cancer" in the last chapter.

On almost every page there is some idea worth thinking about and worth starting some new experiments to prove or disprove. It is a book which will inspire many and infuriate some. To quote Belloc's preface to "Ruthless Rhymes", "And is this true ? It is not true; And if it was, it would not do". Or rather, it does not matter. In the present revolutionary state of biochemistry, such challenging ideas may be more important than carefully checked measurements of unimportant phenomena.

J. D. Bernal

A HUNDRED YEARS OF CHEMICAL INDUSTRY

The Chemical Industry during the Nineteenth Century

A Study of the Economic Aspect of Applied Chemistry in Europe and North America. By Dr. L. F. Haber. Pp. x+292. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 45*s.* net.

THERE is no more rewarding background study for a young man entering the chemical industry than the history of its development during the past hundred years or so. The research chemist will learn much from the successes and failures of his predecessors. Almost unconsciously he will acquire a sense of scale and a perception of values which will help him to relate the worth of his individual work to the future prosperity and expansion of the industry in which he is engaged. The young plant manager will derive encouragement from the accounts of the start of new processes and of operating difficulties successfully overcome by resourceful engineering. A study of the rise and fall of varying methods of manufacture due to different raw materials, different chemical efficiencies and the changing requirements of customers cannot fail to stimulate interest in the economic prosperity of the process he is operating or developing.

The publication of Dr. L. F. Haber's book, "The Chemical Industry during the Nineteenth Century" is therefore to be warmly welcomed.

The book is a mine of detailed information and the accuracy is of a high order. Particularly valuable for the student are the ample footnotes with their references to the original sources. The compilation of the book must have involved the author in an immense amount of devoted labour.

It is not, however, very easy reading, partly on account of the number of detailed facts, some of which, though interesting in themselves, are to a certain extent irrelevant to the main themes of the book, but also because of the rather curious division of the chapters. Some of them deal with special topics, such as "New Schools of Science", "New Technologies" and "The Workers in the Nineteenth Century Chemical Industry", over the whole of the period under review, whereas others deal with the history of such processes as Leblanc soda manufacture and the ammonia–soda process in sections divided into arbitrary periods of time which have no special relation to technical changes or commercial competition. The author, in his introduction, rightly emphasizes the great interest of the changing role of the Leblanc soda trade, but in the book the story is cut into half a dozen sections unrelated except by a certain degree of repetition.

It would be of great interest to the student if the author, at some future date, could write the fascinating story of the development of the alkali industry as a thesis in itself. The main facts and factors involved are already in the present book, but their presentation as a continuous story would bring out far more clearly the reasons for the decline and fall of the Leblanc process and the technical and economic changes behind it.

The chemical industry exists primarily to serve the raw material requirements of other industries. As the standard of living increases, so does the extent and prosperity of consumer industries grow. The chemical industry grows with them.

In the nineteenth century, the remarkable increase in the textile industry in the United Kingdom, and to a lesser extent in the production of glass, paper and soap, brought with it a rapidly increasing demand for soda ash, for bleach, for sulphuric acid and for saltcake. It is difficult to realize to-day that in the decade 1870–80 the demand for bleaching powder, owing to the enormous size of the cotton textile industry, was nearly as big as the demand for soda ash. It was for this reason that, in spite of the chemical elegance of the ammonia–soda process and the great technical advantage of a continuous process as opposed to the batch working of the Leblanc manufacturers, Brunner Mond and Co. were forced to make chlorine and bleaching powder from the liquor of the ammonia–soda process. The daring and technically successful achievement of Dr. Mond in producing chlorine from ammonium chloride (incorrectly described as "calcium chloride" on p. 159) by vaporizing it and passing it over nickel oxide pills was costly, but it served its commercial purpose by preventing the Leblanc manufacturers from increasing the price of bleach and selling soda ash as a by-product at give-away prices. The interesting graph of bleaching powder prices in Appendix 5 illustrates this well.

The sections of the book dealing with the development of the dyestuffs industry make interesting reading, though here again the story suffers from a certain lack of continuity which makes it difficult to follow the economic factors involved.

The chapter entitled "Chemical Manufacturers and their Problems" gives a number of tables illustrating movements in international trade in chemicals and directs special attention to the effect of tariff changes. A particularly vivid example which is quoted is that of the Dingley tariff in the United States. Until the early 'nineties, the United States was by far the most important export market for British alkali manufacturers, taking the enormous quantity of more than 150,000 mixed tons. Within a year or two of the imposition of the tariff, British exports had diminished to a mere trickle.

J. L. S. STEEL

THE STATISTICAL DESCRIPTION OF VEGETATION

Quantitative Plant Ecology

By P. Greig-Smith. Pp. ix+198. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 30*s.*; 6 dollars.

THIS book deals primarily with some of the statistical approaches to the problems of describing the distribution of vegetation and, in a few cases, of species. The basis of these techniques involves concepts such as those of density, frequency and cover, which are first explained and then used to introduce the principles involved in sampling, the arrangement and size of the units of estimation and the comparison of the results of different sets of observations. A considerable part of the book is devoted to the analysis of what is called 'pattern' in vegetation—defined as the departure from randomness of distribution of individuals within the plant community—and then to the possible relationships between the patterns shown by different species and their correlation or lack of correlation in distribution. Finally, consideration is given to the possibility of delimiting plant communities on purely objective grounds and the bearing of this upon the classification of vegetation.

Although one chapter gives examples of correlations between vegetation and the level of environmental factors, the book is not primarily concerned with ecology in the usual sense of the word—the relation between organisms and their environment—or with the quantitative study of these relations as estimated, for example, by weighing, counting or measuring. To this extent the title is a misnomer. It is, indeed, in the reviewer's estimation the only part of the book open to real criticism.

Although ecologists dealing with vegetation have usually accepted the simplest descriptive units which could be clearly defined (hence often a species) as the quantitative basis for correlations between vegetation and environment, most of them at some time have also wished for larger units with objective biological significance. Long ago this was the initial attraction of the methods of the Upsala school, though in that case, as so often since, the hope was soon dispelled. This ideal the author of this work keeps clearly in mind and the great merit of the book is that it discusses at frequent intervals the basic problems which have to be faced in arriving at suitable underlying concepts. It indicates how, in the author's opinion, solutions might be found. While the reader may find himself at times unable to agree with the author, he will certainly also find the discussions thoughtful and stimulating, though, as is often the case in such matters, it is not possible to convey their interest in a short review.

This is a useful and timely book: useful, because it collects most of the pertinent arguments and statistical methods in one volume; timely, because it tries to integrate the large recent accessions of literature in this field and also because it presents and unifies ideas and thus will undoubtedly form a basis for further advances. W. H. Pearsall

SCIENCE FOR STUDENTS OF THE HUMANITIES

Harvard Case Histories in Experimental Science

Edited by James Bryant Conant and Leonard K. Nash. Vol. 1. Pp. xvi+322. Vol. 2. Pp. v+323–639. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1957.) 80*s*. net the set.

The case histories in experimental science introduced to Harvard by J. B. Conant have become widely known as representing an interesting experiment in the teaching of science to non-scientists. The collection of eight of these case histories into two volumes, under Conant's editorship, has now made them easily available to English readers. The 'cases' are concerned with: Boyle's experiments in pneumatics; the overthrow of the phlogiston theory; the early development of the concepts of temperature and heat; the atomic–molecular theory; plants and the atmosphere; Pasteur's study of fermentation; Pasteur's and Tyndall's study of spontaneous generation; the development of the concept of electric charge.

Each 'case' is in the form of a self-contained essay aimed at bringing the reader into the frame of mind of the earlier experimenters and at showing him how difficult it often was for investigators to make a break with tradition and to start thinking along new lines. It is shown how the change in point of view depended jointly on experimentation and on imaginative conjecture, and how the approach was seldom direct, but when seen from our more enlightened point of view seems often to have been roundabout and tortuous. To bring the reader more closely into contact with the mental attitude of the original investigators, skilful use is made of quotations from original papers.

It is difficult for a scientist to assess how far a non-scientist would find these essays interesting or instructive. For that it is best to rely on experience in the United States, where, at Harvard and elsewhere, they have been highly successful, in the hands of skilled teachers, in transmitting something of the principles of scientific investigation to those whose main studies were in the humanities.

To a scientist, however, there is no doubt at all that the essays provide an excellent account of how a series of discoveries came about, and the reader finds himself sharing in the excitement of the early investigators. Most scientists will find much that is new, even in the history of their own subject. I learnt for the first time, for example, how Hauksbee's experiments led him by curiously devious routes from the study of the flash of light which sometimes occurs in the space above the mercury when a barometer tube is shaken, to the discovery of several new phenomena in electrostatics and, in particular, to that of electrostatic induction.

Most degree courses in science are so concerned with imparting the maximum of 'useful' knowledge that neither teachers nor learners often find time to inquire just how some of the concepts they take for granted really arose. It is difficult to avoid being swept along with this rushing stream of education and discovery; but if it is to be education in the true sense, and not just the acquiring of technical knowledge which will 'work' when one has to solve a problem, it is necessary to pause at intervals and ask how some of our present-day scientific concepts first arose.

These volumes will provide quiet backwaters into which the research worker or teacher can turn and linger for a short time to study what has happened to the streams of discovery before he joined it, and before he joins it again in his headlong rush to make those advances in knowledge which will form the subject of 'case histories' in the future.

J. A. Ratcliffe

THEORETICAL OPTICS

Geometrical and Physical Optics

By Dr. R. S. Longhurst. Pp. xvi+534. (London and New York: Longmans, Green and Co., Ltd., 1957.) 60*s*. net.

Without necessarily asking too much from the reader of limited mathematical attainment, Dr. Longhurst has given a most comprehensive account of geometrical and physical optics at degree standard which should be widely welcomed. For the pass or general degree student, the treatment is taken as far as possible along elementary lines. The more difficult mathematical work is grouped into separate sections, for those who have to read more deeply; and modern experimental work, and practical applications of optical techniques, are discussed at a level which should prove both helpful and stimulating to the more advanced student who may later specialize in optics.

The first five chapters deal with the general geometrical theory of the perfect image-forming optical system, the paraxial theory of optical instruments, the determination of the constants of optical systems, and the use of the prism in refractometry and spectroscopy. Next, the mathematical treatment of the wave equation, and the ideas of coherence and wave and group velocity, introduce the wave theory of light. Three chapters on interference follow—treating the interference of two beams by wave-front division, that of two beams by amplitude division, and multiple-beam interferometry. Chapter 10, after a critical discussion of Fresnel's theory of diffraction, deals fully with Kirchhoff's diffraction formula, and then explains the basis on which diffraction patterns are classified as 'Fresnel' or 'Fraunhofer'. Chapter 11, on the single slit, and Chapter 12, on diffraction gratings, between them cover all aspects of Fraunhofer diffraction. Chapter 13 deals separately with the Fresnel type. It is usual (and indeed essential if they are to be intelligible) to dissect interference and diffraction effects in this manner, but it is rarely so constructively done; and it is a great assistance to find practical applications such as the Twyman-Green interferometer, the wave-front shearer, and the Sears-Barrell length-standard work, classified likewise under the appropriate heading.

Chapters 15 and 16 discuss the aberrations of lenses, the means of controlling them in optical systems, and a number of standard lens combinations. The chapter on visual optics deals also with colour; that on photometry is chiefly concerned with standards and with visual photometry. The final chapters deal with the electromagnetic theory, the propagation of light in crystals, optical activity, and the velocity of light. Much has been done since R. T. Birge's review of this last subject in 1941, and a good account of the work up to 1957 is given here.

This last comment summarizes one quite striking feature of the book; that it is the work of an enthusiast who would have his students well informed on current progress. But the whole is unusually well planned for its purpose, from the patient sorting out of the sign convention at the beginning to the arrangement of the severer mathematics for "omission at a first reading"; it is a really excellent book. Dr. Longhurst, in the preface, calls it "a student's textbook". This it most certainly is, but there must be many people well past their student days who will find it to be a valuable work of reference.

G. R. Noakes

HISTORY OF IRON IN BRITAIN

History of the British Iron and Steel Industry from c. 450 B.C. to A.D. 1775

By Dr. H. R. Schubert. Pp. xxi+445+26 plates. (London: Routledge and Kegan Paul, Ltd., 1957.) 60*s*. net.

TOWARDS the end of the fifteenth century a technological discovery was made which revolutionized the iron industry and was, in fact, the harbinger of our modern civilization. From the very beginning of the Iron Age this metal had been produced by the direct reduction of the ores in furnaces of small size in which the temperature normally never attained that required for fusion, though it is certain that on occasion and by accident the sponge iron produced became carburized to such an extent that a molten product—white cast iron—was obtained. As the size, and particularly the height, of the furnace in which the reduction was effected was increased, higher and higher temperatures were attained until, finally, the forerunner of the modern blast-furnace was developed and molten iron was produced deliberately. This great change in technique resulted in a relatively enormous increase in output. It further provides the justification for the division of this really important contribution to the history of technology into two parts, the first concerned with the early history of a process which resulted in a soft sponge iron, the latter in the production of molten cast iron, used at first mainly for the production of military castings, which required a second process for its conversion into a malleable product.

The author, a professional historian, surveys the whole history of the industry from the first introduction of iron to Britain to the time when molten steel was produced commercially by the Huntsman process; but nowhere is his background shown to better advantage than in the skill with which he has revealed the extent to which the introduction of the blast-furnace increased the output of metal obtained. In the course of a few decades the daily output per furnace was raised some seven times. The wide field over which the material has been collected and the great skill with which it has been sifted and woven into a surprisingly coherent story deserve the highest praise.

Of the earliest English blast-furnaces neither picture, description nor remains have been preserved: the furnace, previously supposed to be of this nature, from a drawing in the Public Record Office, was, in fact, a lead furnace erected in Derbyshire about 1552. It is, therefore, from the accounts of the Sussex ironworks, from 1541 onwards, that it has been possible to obtain some idea of the structure as it existed in the early sixteenth century, and the author has been able to reconstruct the main outlines of this piece of equipment, a description which is rendered the more vivid from the excellent coloured frontispiece of a painting by the Flemish artist, Blès.

There are certain minor imperfections in the text: W. Goland of Appendix 1, for example, should surely be Prof. W. Gowland, and that the author is not himself a metallurgist is here and there apparent. It is this fact, presumably, which leads him to perpetuate the heresy that there was some special virtue or magic in ores containing small amounts of manganese and titanium which rendered it possible for primitive metallurgists to produce a steel, as distinct from soft iron, in the early direct furnace. It is quite easy to do this even in the complete absence of either of those elements by allowing the reduced sponge to remain in contact for a sufficient time with the glowing charcoal.

Despite such blemishes, however, there can be no question that the volume under consideration is one of quite outstanding merit, for which the archæologist and technologist alike owe a very deep debt to the author himself and to the Iron and Steel Institute, through the support of which the researches here recorded were carried out.

F. C. Thompson

Nuclear Engineering

Edited by Prof. Charles F. Bonilla. (McGraw-Hill Series in Nuclear Engineering.) Pp. xi+85 (London: McGraw-Hill Publishing Company Ltd., 1957.) 94*s*.

TWELVE specialists have collaborated in writing this book. Of the 800 pages, 170 are devoted to nuclear physics and associated subjects, 100 to reactor physics and shielding theory, about 300 to thermal and structural considerations, about 60 to instrumentation and less than 20 to metallurgy.

Although the nuclear physics is well presented, a more rigorous selection of topics with greater emphasis on those of immediate importance would have pleased the reviewer. There is a well-written chapter on radiation protection, which includes a clear explanation of the units used, the variety of which usually bewilders students.

Reactor physics is not allotted enough space and too much is attempted in the space available. In covering neutron cycles, flux, extrapolation distance, one group, multigroup and age theories, and resonance absorption effects, as well as discussing transport and diffusion theories and other topics in the space of 30 pages it has only been possible to survey the subject.

The real value of the book lies in its treatment of thermal and structural aspects of reactors, and for this section it can be recommended. There is a stimulating discussion of the potentialities and problems of non-elastic design methods.

Concluding chapters deal with reactor types and legal aspects of nuclear power.

As a text-book it suffers from having too many authors; as a work of reference its value is enhanced by the many references included, particularly on heat transfer, but weakened by an inadequate index.

W. Murgatroyd

A Revision of the Australian Chafers (Coleoptera: Scarabaeidae: Melolonthinae)

By E. B. Britton. Vol. 1. Pp. viii+186+42 plates. (London: British Museum (Natural History), 1957.) 80*s*.

IT is now generally recognized that an effective investigation into the biology and control of any group of animals must be based upon a sound taxonomy, but all too frequently this basic requirement remains unfulfilled until a very late stage, when already much effort has been wasted because of faulty identification. In the present volume the systematics of an important group of beetles is placed upon a satisfactory footing in a comparatively early stage of the investigation. The damage done by the Melolonthinae as a whole is of considerable economic importance, and it is chiefly due to the root-feeding habits of the larvæ. A great variety of plants are attacked by one or other of the species: grasses and various field crops including maize and sugar cane and also vegetables and fruit. Sometimes a considerable amount of damage is done by the adults of some species that feed upon the leaves of shade and fruit trees and also injure vines. It is somewhat surprising to find that all the pest species are indigenous, as indeed are all other Melolonithinae of Australia.

The volume is exceptionally well illustrated; there are 524 figures of which all but 25 drawings of the whole insect are arranged in 42 plates at the end. Most of the figures are simple but good outline drawings of the male genitalia and of the head and prothorax of the different species. The keys are well done in the best modern style, and there would seem to be no difficulty in choosing between the alternatives offered in each couplet. Thirteen tribes are recognized of which no less than ten are described as new. The Sericini and four of the new tribes are dealt with in this first volume. These five tribes include 203 species of which 67 are described for the first time.

H. E. Hinton

Fibre Microscopy

Its Technique and Application. By Dr. J. L. Stoves. Pp. viii+276. (London: National Trade Press, Ltd., 1957.) 50*s*. net.

SO much is the make-up of all biological tissues of a fibrous construction, so much does man put numerous animal and vegetable fibres to supplementary uses, and so much has he now extended the idea into similar fields more purely of his own invention, that there is a continual need for good and up-to-date writing on the subject, and a new book of the kind on fibre microscopy can scarcely fail to be most acceptable to all sorts of readers. Dr. Stoves, out of his wide experience and contacts in such matters, has certainly provided one in the volume noticed here, directed to "students, laboratory assistants, analysts and research workers"—and that means, among many others, archæologists and criminologists, for example; and he has spread its informative coverage over all the latest developments, including, of course, phase-contrast, interference and reflexion microscopy and, of ever-growing importance these days in spite of the expense, electron microscopy (plus, it should be mentioned, a chapter on metal shadow-casting in visible microscopy). He applies them then to the examination of almost anybody's fibres, so to speak. There are also excellent bibliographies and suggestions for further reading, indexes of animals and plants, and lists of stains and staining reactions. Altogether, this is a very worthwhile book indeed.

W. T. Astbury

Bakteriophagie 1917 bis 1956

Zugleich ein Vorschlag zur Dokumentation wissenschaftlicher Literatur. Von Dr. Hansjürgen Raettig. Teil 1: Einführung—Sachregister—Stichwortverzeichnis. Pp. xix+215. Teil 2: Autorenregister. Pp. iii+344. (Stuttgart: Gustav Fischer Verlag, 1958.) 44 D.M.

THESE two little books are intended as a guide to the literature on bacteriophage published between 1917 and 1951; they are a monument to German industry and thoroughness. Vol. 2 lists under authors no less than 5,655 references. Looking up fifty references, some of them from rather obscure journals, failed to reveal one which was not listed, and quite a large number from Russian journals are included. Vol. 1 classifies the material under subjects; here the arrangement is good but not perfect. A few omissions were detected: for example, *Escherichia* is unaccountably missing on p. 137. The books suffer, as do most bibliographies, from the defect that one cannot tell which of the many references are the really important ones.

The format is excellent; the limp covers in an attractive blue-grey add to the appeal of the volumes. Anyone who has to write an article, a review or even a book on phage will find that Dr. Hansjürgen has saved him much of his labour.

C. H. Andrewes

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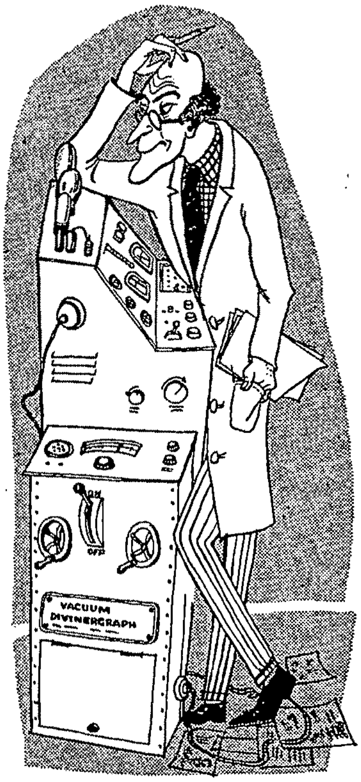

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SEPARATION OF LIGHT AND DARK PHASES IN THE PHOTOSYNTHESIS OF ISOLATED CHLOROPLASTS

By Dr. ACHIM V. TREBST, HARRY Y. TSUJIMOTO and Prof. DANIEL I. ARNON
Laboratory of Plant Physiology, Department of Soils and Plant Nutrition, University of California, Berkeley

THE recognition of a 'dark', that is, a thermochemical phase in photosynthesis, had its origin in Blackman's findings[1], that at high, but not at low, light intensities the rate of photosynthesis is dependent on temperature. Warburg named this thermochemical stage of photosynthesis the Blackman reaction and established its sensitivity to cyanide[2]. The present communication reports the physical separation, by fractionating chloroplasts, of the light and dark phases of photosynthesis. The light phase was completed first and was then followed by the dark phase. The two phases, when carried out consecutively, yielded essentially the same final photosynthetic products as the continuously illuminated complete chloroplast system.

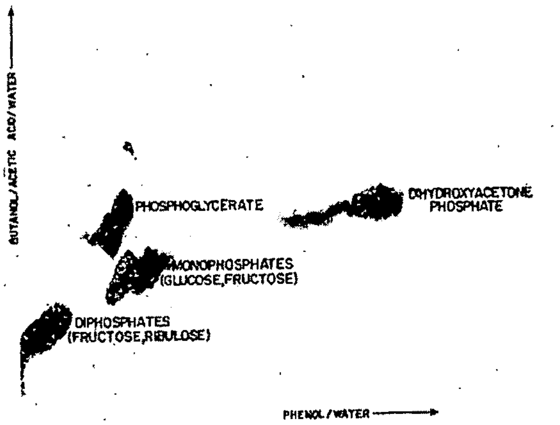

Fig. 1. Radioautograph of a chromatogram showing products of photosynthetic $^{14}CO_2$ assimilation by illuminated chloroplasts. Experimental conditions as in treatment 3 of Table 1

It has recently been shown that the organization of the living cell is not necessary for photosynthesis as it is usually defined[3]. Reduction of carbon dioxide to carbohydrates accompanied by oxidation of water to oxygen is carried out, at low temperatures and with no energy supply except visible light, by isolated chloroplasts, unaided by other cellular particles or enzyme systems[4-12,13-15].

This extracellular photosynthesis by chloroplasts differs from that process in whole cells notably in that it proceeds independently of concurrent cellular activities, such as respiration, which cannot be divorced from photosynthesis in intact cells[16]. Isolated chloroplasts, if freed from other cytoplasmic impurities, do not respire[6,10,17]—a conclusion which has recently received strong support from the work of James and Das[18]. The products of photosynthesis by isolated chloroplasts are mainly carbohydrates; amino-acids were not formed in the experiments reported here (Figs. 1, 2, 3). The role of amino-acids in photosynthesis has assumed special interest in the light of Warburg's[19] recent findings with *Chlorella* cells.

Although extracellular photosynthesis by chloroplasts cannot be equated in all respects with photosynthesis in intact cells it retains the principal features of that process, and permits their investigation in isolation from concurrent cellular activities. The separation of photosynthesis by chloroplasts from the structural and functional complexity of the

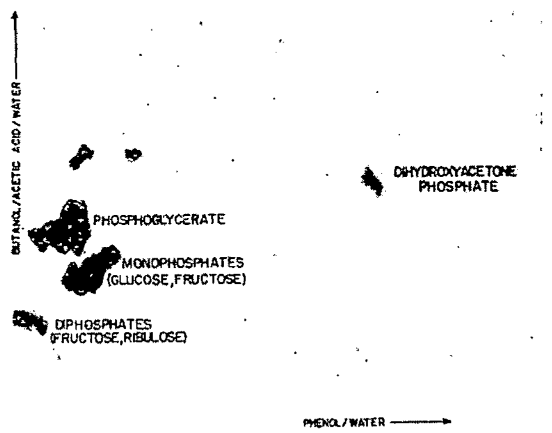

Fig. 2. Radioautograph of a chromatogram showing products of dark $^{14}CO_2$ assimilation by a chlorophyll-free extract of chloroplasts, supplemented with 'assimilatory power' formed in a previous light reaction. Experimental conditions as in treatment 1 of Table 1

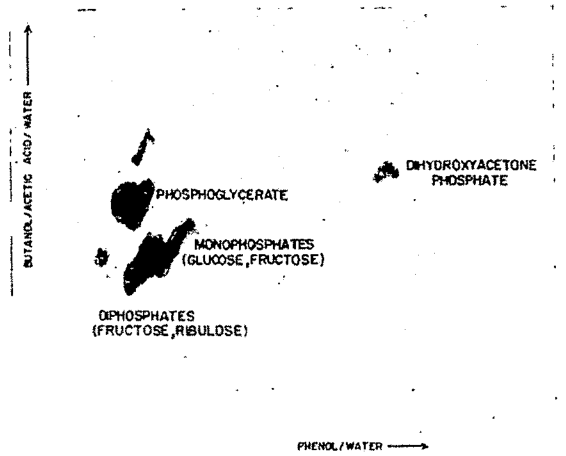

Fig. 3. Radioautograph of a chromatogram showing products of dark $^{14}CO_2$ assimilation by a chlorophyll-free extract of chloroplasts supplemented with adenosine triphosphate, and reduced triphosphopyridine nucleotide formed by the oxidation of isocitrate. Experimental conditions as in treatment 9 of Table 3

whole cell has provided a particularly useful approach to the study of those problems in photosynthesis in which a clear distinction from the dark reactions of respiration is especially pertinent. One of these problems is the relation between the light and dark reactions in photosynthesis.

The Photochemical Phase of Photosynthesis : Oxygen Evolution and the Generation of Assimilatory Power

Systematic studies of the photochemical reactions of isolated chloroplasts, without the participation of carbon dioxide, began with the experiments of Hill[20] in 1937. Recent progress which led to the characterization of the physiological products of these reactions came from two directions : the finding of a photochemical phosphorylation system in chloroplasts[21] and, as will be discussed next, the identification of the reductant for the assimilation of carbon dioxide.

Vishniac and Ochoa[22], Tolmach[23], and Arnon[24] found that, in light, isolated chloroplasts can reduce pyridine nucleotides and simultaneously evolve oxygen, if this photochemical reaction is coupled with an enzyme system capable of utilizing the reduced pyridine nucleotides. A direct reduction of pyridine nucleotides by illuminated chloroplasts, as measured by the accumulation of the reduced product, was demonstrated by San Pietro and Lang[25]. Evidence has also been obtained that triphosphopyridine nucleotide rather than diphosphopyridine nucleotide is preferentially reduced in light[26,27].

Another photochemical process occurring in isolated chloroplasts is photosynthetic phosphorylation, that is, the utilization of light energy for the synthesis of high-energy phosphate bonds in accord with the overall reaction 1, where P represents orthophosphate and ADP and ATP represent adenosine diphosphate and triphosphate, respectively.

$$n.\mathrm{ADP} + n.\mathrm{P} \xrightarrow[\text{chloroplasts}]{\text{light}} n.\mathrm{ATP} \qquad (1)$$

In reaction 1, all the captured light energy is converted into the high-energy pyrophosphate bonds of adenosine triphosphate. This type of photosynthetic phosphorylation has been named cyclic photophosphorylation[21].

The connexion between photosynthetic phosphorylation and the reduction of triphosphopyridine nucleotide was not clear at first, but was later, rather unexpectedly, found to be very direct[21,26,28]. It is shown in reaction 2.

$$2\mathrm{TPN} + 2\mathrm{ADP} + 2\mathrm{P} + 4\mathrm{H_2O} \xrightarrow[\text{chloroplasts}]{\text{light}} 2\mathrm{TPNH_2} + 2\mathrm{ATP} + \mathrm{O_2} + 2\mathrm{H_2O} \qquad (2)$$

In reaction 2, only part of the light energy absorbed by chlorophyll is trapped in the pyrophosphate bond of adenosine triphosphate ; the remainder is used for the formation of reduced triphosphopyridine nucleotide. Reaction 2 may therefore be viewed as representing the essential photosynthetic events in green plants : the transformation of light energy into chemical energy accompanied by the evolution of oxygen. The newly formed chemical energy is deposited in two substances, which have been jointly termed 'assimilatory power'[21] : a reductant (reduced triphosphopyridine nucleotide) and an energy-rich phosphorus compound (adenosine triphosphate).

The stoichiometry of reaction 2, when measured under appropriate experimental conditions[21,26,28], indicates that the formation of four hydrogen equivalents, needed for reduction of one mole of carbon dioxide to the level of carbohydrate (= CH.OH), is accompanied by the evolution of one mole of oxygen, as would be expected from the well-known photosynthetic ratio CO_2/O_2 of 1. In addition, two moles of adenosine triphosphate are formed. Whether these fulfil the requirements for adenosine triphosphate in the assimilation of carbon dioxide cannot as yet be stated with certainty[12]. If, however, reaction 2 cannot by itelf supply enough adenosine triphosphate for carbon assimilation then it could be supplemented, to a varying degree, by cyclic photophosphorylation (reaction 1).

To recapitulate, it is envisaged that in photosynthesis by isolated chloroplasts the photochemical events are the evolution of oxygen coupled with the generation of 'assimilatory power' (reaction 2), and cyclic photophosphorylation (reaction 1). It is assumed that the cell has suitable regulatory mechanisms for maintaining a balance between these two reactions[21]. What remains to be demonstrated is that the products of these photochemical reactions, reduced triphosphopyridine nucleotide and adenosine triphosphate, are used for the dark assimilation of carbon dioxide to the level of carbohydrates.

The Dark Phase of Photosynthesis : Carbon Dioxide Assimilation

Experiments to test the effectiveness of the products of photochemical reactions in carbon assimilation in the dark were undertaken as follows. Substrate amounts of 'assimilatory power' were first generated in light in the absence of carbon dioxide. At the end of the light reaction carbon-14 dioxide was supplied in the dark, and, after an incubation period, its total fixation was measured. The newly formed radioactive compounds were identified by paper chromatography and radioautography[7].

In carrying out the dark reaction it soon became apparent that the green portion of the chloroplasts was superfluous. In accord with previous results[8,9,11], the chloroplast enzymes responsible for carbon assimilation were present in the chlorophyll-free, water-soluble portion of the chloroplasts ('stroma'). The water-insoluble green portion of the chloroplasts ('grana') was therefore removed by centrifugation after the light reaction was completed. This separation by centrifugation was possible since the chloroplasts used were already disrupted through immersion in the hypotonic reaction mixture. $^{14}CO_2$ was then supplied to the chlorophyll-free extract which contained, in addition to the soluble enzymes, catalytic amounts of sugar phosphate[11] and the two components of assimilatory power generated in the previous light reaction : reduced triphosphopyridine nucleotide and adenosine triphosphate.

As shown in Table 1, in the presence of 'assimilatory power', the chlorophyll-free extract was able to fix $^{14}CO_2$ in the dark. Only feeble fixation occurred in the dark without the components of assimilatory power (treatments 1 and 2). The dark fixation of carbon dioxide by the chlorophyll-free extract supplemented with 'assimilatory power' was comparable with fixation in the light where $^{14}CO_2$ was supplied at the beginning of the illumination period to a reaction mixture containing the complete chloroplast system. Here 'assimilatory power' was formed continuously in the light and used at once for carbon dioxide fixation (treatment 3). Very little fixation

Table 1. CARBON DIOXIDE FIXATION BY A CHLOROPHYLL-FREE EXTRACT AND A COMPLETE CHLOROPLAST SYSTEM FROM SPINACH

Treatment	$^{14}CO_2$ fixed (counts/min.)
1. Chlorophyll-free extract, dark + A.P.*	134,000
2. Chlorophyll-free extract, dark − A.P.*	9,000
3. Complete chloroplast system, light	200,000
4. Complete chloroplast system, dark	20,000

* A.P. = Assimilatory power, that is, reduced triphosphopyridine nucleotide and adenosine triphosphate formed in light by chloroplasts.

The complete chloroplast system contained in a final volume of 2·5 ml. 'broken' chloroplasts (ref. 12) containing 0·5 mgm. chlorophyll, chlorophyll-free extract (ref. 12) equivalent to 2 mgm. of chlorophyll and the following in micromoles: *tris* (hydroxymethyl) aminomethane buffer, *p*H 7·5, 80; magnesium chloride, 5; manganese chloride, 2; sodium ascorbate, 10; glucose-1-phosphate, potassium salt, 0·3; sodium phosphate *p*H 7·5, 5; adenosine diphosphate, 2; and triphosphopyridine nucleotide, 2. The reaction was carried out at 20° C. for 30 min.; gas phase, argon. In treatments 3 and 4, 10 micromoles sodium bicarbonate, containing $^{14}CO_2$, were injected at the beginning and the reaction vessels were illuminated or left in the dark, respectively. In treatment 1, the reaction mixture was first illuminated without the addition of bicarbonate. After 30 min., the particles containing chlorophyll were removed by centrifugation, and the chlorophyll-free supernatant fluid was incubated in the dark for 30 min. with 1·5 micromoles cystein and 10 micromoles of sodium bicarbonate containing $^{14}CO_2$. The same procedure was followed in treatment 2 as in treatment 1 except that adenosine diphosphate and triphosphopyridine nucleotide were omitted.

occurred in the complete chloroplast system in the dark (treatment 4).

The products of carbon dioxide assimilation were found to be the same whether it occurred during continuous illumination (Fig. 1) or in the dark, at the expense of assimilatory power generated during a preceding light period (Fig. 2). They included hexose and pentose mono- and di-phosphates, phosphoglyceric acid, dihydroxyacetone phosphate, and small amounts of phosphoenolpyruvate and malate.

Carbon dioxide fixation in the dark was sensitive to cyanide. The inhibition at 10^{-3} *M* cyanide varied between 60 and 80 per cent.

Assimilatory Power from Outside Sources

The conclusion that adenosine triphosphate and reduced triphosphopyridine nucleotide are the components of assimilatory power required by chloroplast enzymes for carbon dioxide assimilation was tested by supplying these substances, in substrate quantities, from external sources instead of generating them in a light reaction. The results are shown in Table 2.

Reduced triphosphopyridine nucleotide, when prepared either chemically, or enzymatically with isocitric dehydrogenase, was, in combination with adenosine triphosphate, as effective in bringing about carbon dioxide assimilation by the chlorophyll-free extract of chloroplasts as the 'assimilatory power' generated by illuminated chloroplasts. The omission of reduced triphosphopyridine nucleotide or its substitution by reduced diphosphopyridine nucleotide cut carbon dioxide fixation approximately in half. No significant fixation occurred when both reduced triphosphopyridine nucleotide and adenosine triphosphate were absent.

Table 2. CARBON DIOXIDE FIXATION IN THE DARK BY A CHLOROPHYLL-FREE EXTRACT OF CHLOROPLASTS, SUPPLEMENTED WITH ADENOSINE TRIPHOSPHATE (ATP) AND REDUCED TRIPHOSPHOPYRIDINE NUCLEOTIDE ($TPNH_2$) OF PHOTOSYNTHETIC AND NON-PHOTOSYNTHETIC ORIGIN

Treatment	$^{14}CO_2$ fixed counts/min.
1. Chlorophyll-free extract + A.P.*	96,000
2. Chlorophyll-free extract − A.P.*	4,000
3. Chlorophyll-free extract + ATP†	43,000
4. Chlorophyll-free extract + (ATP† + $DPNH_2$‡)	50,000
5. Chlorophyll-free extract + (ATP† + $TPNH_2$§)	97,000
6. Chlorophyll-free extract + (ATP† + $TPNH_2$‖)	140,000

Treatments 2–6 were the same as treatment 2 in Table 1, except for the indicated additions.

* A.P. = Assimilatory power, that is, ATP + $TPNH_2$, formed in light by chloroplasts (see treatment 1, Table 1).

† Two micromoles (from animal sources, Sigma Chemical Co.).

‡ $DPNH_2$ = reduced diphosphopyridine nucleotide (2 micromoles) enzymatically prepared, Sigma Chemical Co.

§ 1·4 micromoles, enzymatically prepared with isocitric dehydrogenase. The enzyme itself was without effect on the course of the reaction.

‖ 2 micromoles, chemically prepared, Sigma Chemical Co.

In the dark fixation experiments described so far, reduced triphosphopyridine nucleotide was supplied in substrate quantities, since no provision was made for its regeneration, as would be the case with illuminated chloroplasts. However, carbon dioxide assimilation in the dark also proceeds with a catalytic amount of reduced triphosphopyridine nucleotide if its supply is maintained by an enzymatic reaction catalysing a triphosphopyridine nucleotide-dependent oxidation of an appropriate substrate. Parallel experiments have shown that in addition to the enzymes previously identified[8,9,11], the chlorophyll-free extract of chloroplasts contained glucose-6-phosphate dehydrogenase, 6-phosphogluconic acid dehydrogenase and isocitric dehydrogenase which catalyse, respectively, reactions 3, 4 and 5[29,30].

$$\text{Glucose-6-phosphate} + \text{TPN} \longrightarrow \text{6-phosphogluconate} + \text{TPNH}_2 \quad (3)$$

$$\text{6-Phosphogluconate} + \text{TPN} \longrightarrow \text{ribulose-5-phosphate} + \text{CO}_2 + \text{TPNH}_2 \quad (4)$$

$$\text{D-Isocitrate} + \text{TPN} \xrightarrow{\text{Mn}^{++}} \alpha\text{-ketoglutarate} + \text{CO}_2 + \text{TPNH}_2 \quad (5)$$

Table 3 shows that catalytic amounts of reduced triphosphopyridine nucleotide (0·3 micromole) generated *in situ* by the oxidation of one of three substrates, glucose-6-phosphate, 6-phosphogluconic acid or isocitric acid, were, in combination with adenosine triphosphate, as effective for carbon dioxide assimilation in the dark as substrate amounts of reduced triphosphopyridine nucleotide (2 micromoles) used in previous experiments (Tables 1 and 2). Carbon dioxide fixation was greatly diminished by omitting

Table 3. CARBON DIOXIDE FIXATION IN THE DARK BY A CHLOROPHYLL-FREE EXTRACT OF CHLOROPLASTS, SUPPLEMENTED WITH ADENOSINE TRIPHOSPHATE (ATP) AND CATALYTIC AMOUNTS OF TRIPHOSPHOPYRIDINE NUCLEOTIDE (TPN) REDUCED AT THE EXPENSE OF ONE OF THREE HYDROGEN DONORS

Treatment	Hydrogen donor	$^{14}CO_2$ fixed (counts/min.)
1. Chlorophyll-free extract + TPN*	glucose-6-phosphate†	3,300
2. Chlorophyll-free extract + ATP†	,,	45,000
3. Chlorophyll-free extract + TPN* + ATP†	,,	171,000
4. Chlorophyll-free extract + TPN*	6-phosphogluconate†	7,200
5. Chlorophyll-free extract + ATP†	,,	17,000
6. Chlorophyll-free extract + TPN* + ATP†	,,	190,000
7. Chlorophyll-free extract + TPN*	Isocitrate‡	16,000
8. Chlorophyll-free extract + ATP†	,,	95,000
9. Chlorophyll-free extract + TPN* + ATP†	,,	292,000

* 0·3 micromole.

† 2 micromoles.

‡ 5 micromoles of isocitrate plus 2 micromoles of ribose-5-phosphate (R-5-P) were added.

Other experimental conditions as in treatment 2 of Table 1.

either adenosine triphosphate or triphosphopyridine nucleotide. Moreover, in the absence of reduced triphosphopyridine nucleotide little, if any, sugar phosphate was found among the products of fixation.

In the experiments represented by Table 3 photosynthesis has been replaced by a chemosynthesis in the sense that the reductant required for carbon dioxide assimilation by chloroplast enzymes was being continuously generated at the expense of a chemical hydrogen donor, a sugar phosphate or an organic acid, instead of light energy. As shown in Fig. 3, the products of this chemosynthesis by chloroplast enzymes are the same as those found during photosynthesis (Fig. 1).

In the present investigation, the chlorophyll-free extract of isolated chloroplasts was the source of all the enzymes required for the dark synthesis of phosphorylated sugars from carbon dioxide. Other cell-free systems have been described as models for photosynthetic carbon assimilation. Racker[31] used for the synthesis of hexose monophosphate a multi-enzyme system in which spinach leaves served as a source or the pentose cycle enzymes. These were supplemented[32] with glyceraldehyde-3-phosphate dehydrogenase and aldolase from rabbit muscle and phosphoglyceric acid kinase from yeast. The reductant was reduced diphosphopyridine nucleotide, rather than reduced triphosphopyridine nucleotide as in our experiments, and was generated either with molecular hydrogen and a diphosphopyridine nucleotide-linked hydrogenase from a bacterial source or with alcohol and an alcohol dehydrogenase from yeast. Fager[33] prepared from whole spinach leaves a protein fraction which fixed carbon dioxide not to the level of sugars but as phosphoglyceric and pyruvic acids. The rate of carbon dioxide fixation was increased when this fraction was illuminated in the presence of chloroplast fragments; in his system the addition of diphospho- or triphospho-pyridine nucleotides had no effect, whereas that of adenosine triphosphate was inhibitory to carbon dioxide fixation in both light and dark.

General Considerations

In whole cells the light and dark phases of photosynthesis were investigated by techniques of intermittent illumination and experiments on induction phenomena[2,34–38]. Evidence began to accumulate[37,39,40], and was later strengthened by experiments with radiocarbon[41–45], in support of the view that carbon assimilation occurs during the dark phase of photosynthesis. Pre-illuminated cells retained for a short time, measured in minutes[42–44] or seconds[45], the ability to fix carbon dioxide afterwards in the dark. Benson and Calvin[42,43] interpreted this dark fixation as having been accomplished by a "reducing power" formed during the pre-illumination period, whereas Gaffron *et al.*[45] considered that pre-illumination produced an acceptor which was carboxylated during the dark carbon dioxide 'pick-up'. No experimental evidence was adduced in either case for the identity of the postulated short-lived product(s) of the photochemical reactions.

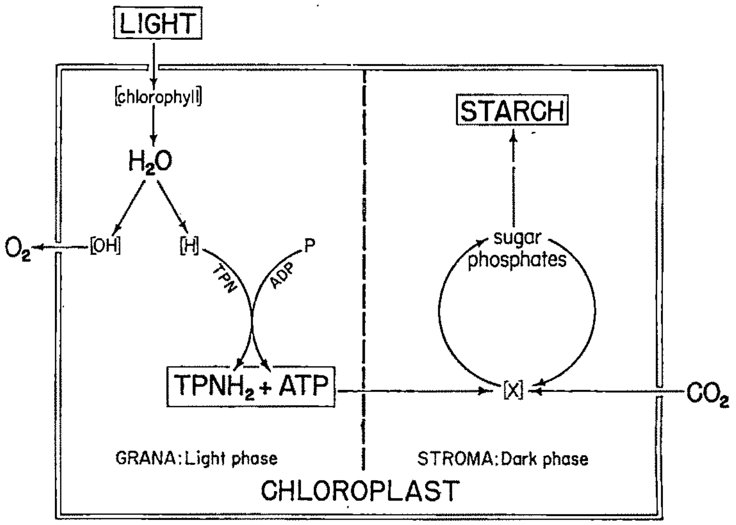

Fig. 4. Scheme for photosynthesis by isolated chloroplasts. In the light phase, photolysis of water, catalysed by 'grana', results in the evolution of oxygen and the generation of assimilatory power comprising two components: reduced triphosphopyridine nucleotide ($TPNH_2$) and adenosine triphosphate (ATP). In the dark phase, assimilatory power is used by the enzymes in the 'stroma' for the assimilation of carbon dioxide in reactions independent of light

Photosynthesis by isolated chloroplasts was found to lend itself to a physical separation into a light phase concerned with the generation of a stable assimilatory power, chemically defined as adenosine triphosphate and reduced triphosphopyridine nucleotide, and a dark phase during which the assimilatory power is used for carbon assimilation. A diagrammatic scheme of photosynthesis by chloroplasts, based on these findings, is shown in Fig. 4.

The separation of the light and dark phases of photosynthesis in isolated chloroplasts was aided by the association of each phase with a different portion of the chloroplast. The dark phase of photosynthesis was found to be associated solely with the water-soluble chlorophyll-free extract. The light phase was, as would be expected, localized in the 'grana' fraction which contains the chlorophyll pigments. However, the light phase appears to involve, in addition to the 'grana', some 'stroma' factors. At least one of these, the pyridine nucleotide-reducing factor[26,21,27], must be present if the generation of 'assimilatory power' is to occur in the light.

The CO_2-fixing enzymes are loosely associated with the chlorophyll pigment system in chloroplasts, and in photosynthetic bacteria[46] do not appear to have formed any structural association at all. Why then should carbon assimilation continue to be regarded as an essential part of photosynthesis? Carbon dioxide assimilation by chloroplast enzymes can be studied as a dark process independent of the photosynthetic pigment system. The basic feat of photosynthesis, the conversion of light into useful chemical energy, is accomplished here through the formation of adenosine triphosphate and reduced triphosphopyridine nucleotide (equations 1 and 2). In the living cell these are present in catalytic amounts and hence the trapped light energy is usually, although perhaps not always[21], stored by coupling their formation with carbon assimilation. *In vivo*, the photochemical phase of photosynthesis is therefore tightly bound to carbon assimilation. But in isolated chloroplasts, adenosine triphosphate and reduced triphosphopyridine nucleotides can be made to accumulate in substrate amounts and their accumulation is a direct measure of the photosynthetic process. Here photosynthesis may be considered as having been completed before carbon assimilation begins. The key problem of photosynthesis, the conversion of light into useful chemical energy, need not, therefore, be enmeshed in the dark enzymatic reactions responsible for the synthesis of carbohydrates.

We are indebted to Dr. F. R. Whatley for the preparation of chloroplasts. We were aided in this investigation by grants from the U.S. Public Health Service and the Office of Naval Research.

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THE JOHN CURTIN SCHOOL OF MEDICAL RESEARCH, AUSTRALIAN NATIONAL UNIVERSITY

ON March 27, Sir Howard Florey, in the presence of the Prime Minister of Australia, the Right Hon. R. G. Menzies, opened the new building of the John Curtin School of Medical Research at the Australian National University in Canberra. The National University was founded in 1946 as a national centre for research and research training, initially in the fields of physical sciences, medical sciences, and the social sciences.

There had long been complaints in Australia that many of the most able scientists left the country because of the greater attractions in universities and research institutions in Great Britain. Such complaints applied more to the medical sciences than to other natural sciences, for which the large and varied laboratories of Commonwealth Scientific and Industrial Research Organization provided first-class facilities, whereas the only medical research institute in Australia with an international reputation was the relatively small Walter and Eliza Hall Institute in Melbourne.

In a report to the Commonwealth Government in 1944, Sir Howard Florey suggested that a national institute for advanced medical sciences should be set up in Australia, and the John Curtin School of Medical Research, established as an integral part of a University devoted to research and research training, is the result of this suggestion. Sir Howard Florey was intimately associated with the development of the School from the time of his report until 1955, and the building he opened on March 27 is a monument to his inspiration and drive. There were no laboratories in Canberra in 1948 when the first professor was appointed, so the departments were started in laboratory space generously lent by several institutions—biochemistry at the Commonwealth Serum Laboratories, Melbourne; medical chemistry at the Wellcome Research Institution in London; microbiology at the Walter and Eliza Hall Institute in Melbourne; experimental pathology in Sir Howard Florey's Laboratories in Oxford and physiology in the University of Otago in New Zealand.

In 1951, temporary laboratories were built in Canberra, and these were occupied between 1952 and 1957, when the departments transferred to the present building (Fig. 1). This is a brick building about 170,000 sq. ft. in floor area. It is built in an H-shape, with four wings for laboratories (which are mainly confined to the upper two floor-levels) and a central spine housing lecture theatre, seminar rooms, offices, tea rooms and library. The lower levels of the building house many of the service departments: store, photography, media kitchens, mechanical plant, etc. In addition, there are two animal houses, each

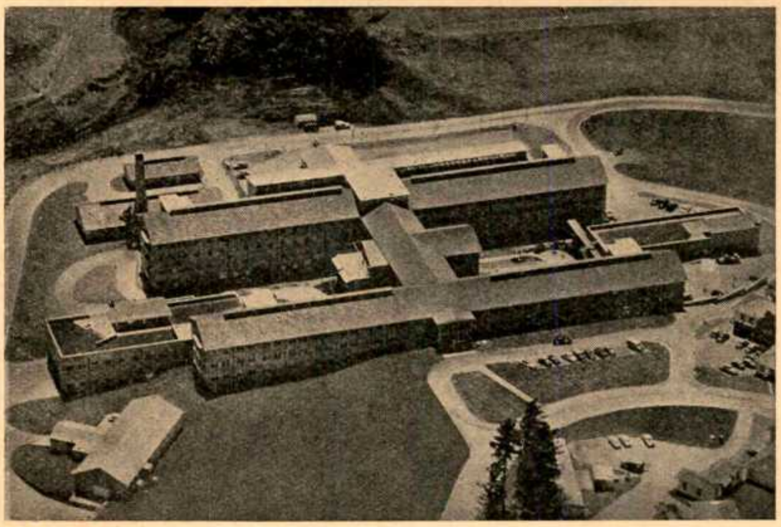

Fig. 1. The John Curtin School of Medical Research, Australian National University, Canberra

of some 7,000 sq. ft. floor area—one for non-infected and the other for infected animals; an animal-breeding establishment some four miles away, and a large light-engineering workshop.

The laboratory wings have on the south side laboratories 20 ft. deep and on the north side service rooms (hot rooms, cold rooms, etc.) and studies 14 ft. deep. The laboratory layout on each floor-level is adapted to the needs of the particular department, but within the departments it follows a standard plan.

At present there are five departments—biochemistry, experimental pathology, medical chemistry, microbiology and physiology. Prof. A. H. Ennor, head of the Department of Biochemistry, is also dean of the School. His department comprises nine staff and five research students, and is concerned principally with enzymology of phosphorylated guanidines. Prof. F. C. Courtice, well known for his researches on physiology of lymph flow, etc., has just been appointed to the chair of experimental pathology. Prof. Adrien Albert heads a group of seven research workers and two research students in the Department of Medical Chemistry. His work on heterocyclic chemistry is familiar to most British scientists, and he now has greatly increased facilities for this work. Prof. F. Fenner, with seven staff members and eight research students, is investigating various aspects of animal virology, principally with the pox viruses and influenza viruses. The Department of Physiology, headed by Prof. J. C. Eccles, specializes in neurophysiology. Prof. Eccles is at present president of the Australian Academy of Science. His distinguished investigations made by micro-electrode methods are widely known, and he is assisted in this work by seven staff members and four research students.

At present the total research staff is about forty and there are some twenty Ph.D. students; but the John Curtin School of Medical Research is still in the process of growth, both in the sense that several new departments will be developed over the next few years to fill in gaps in the present structure, and in the development of each individual department. The new building just opened by Sir Howard Florey provides excellent facilities in a wide range of the medical sciences and already the School is established as a research institution well known throughout the world.

HIGH ENERGY NUCLEAR PHYSICS

THE annual international conference for 1958 on High-Energy Nuclear Physics, which was held in Geneva during June 30–July 5 under the sponsorship of the International Union of Pure and Applied Physics was the successor to those that have been held annually in Rochester, New York, for the past seven years. Over these years the size and duration of the Conference had increased from a small one-day meeting to a full week of intensive sessions recognized as the most important conference on high-energy physics of the year. It was the general opinion at Rochester in 1957 that the volume of effort and the number of contributions had grown to such an extent that the traditional system whereby each contributor presented the results of his experiments had become unworkable and, short of the undesirable step of limiting the scope of the conference still further, it was evident that some new method of presenting the material had to be tried. This year at the European Centre for Nuclear Research (C.E.R.N.) the conference was divided into ten half-day sessions and all contributions in a particular field were presented to the conference by one person, the rapporteur, whose job it was to introduce the subject and to present and to explain the significance of the results obtained. The talks by the rapporteurs were expected to take up approximately half the session and the other half was left for discussion or for the presentation of special papers which did not fit well into the rapporteur's general scheme. The success of this procedure depends very much on the rapporteur. Contributors were asked to submit their papers to him some four weeks before the plenary sessions. Organizing sessions were arranged on the three days preceding the conference proper to enable participants to meet their rapporteur and if necessary to discuss their contributions with him. As an additional preliminary rapporteurs were asked, prior to the Conference, to provide participants with a reading list which would serve as an introduction to the subjects.

The general opinion at the end of the Conference was that the new method of presentation had been enough of a success for the method to be tried again. It was most successful where the rapporteurs, having been selective in the choice of their material, had leisure to present it in a critical way and not merely as a report of a large number of different experiments.

One of the main disadvantages of the rapporteur system lies in the fact that the reports are very concentrated. Contributors tended to remain anonymous with this method of presentation and it was felt that some advantage would have been gained if mimeographed sheets had been made available before each session, giving the title and authors of the contributions so that further details could the more easily have been sought from them afterwards. Tables of important results would also have proved most valuable. The next International Conference is expected to be held in Moscow in July 1959, where the organizing sessions are to be enlarged to enable contributors to present their results in greater detail to the rapporteur and to others working in the same field.

The first plenary session was devoted to experimental and theoretical reports on nuclear structure. Most of the results reported concerned high-energy electron scattering. Both the charge and magnetic-moment scattering of electrons by protons differs markedly from that obtained on the assumption of a point particle. The results suggest a root-mean-square value for the charge radius equal to that for the magnetic moment, both being equal to 0·8 fermi (1 fermi = 10^{-13} cm.) for the proton, and a similar value for the radius of the neutron magnetic moment distribution, obtained by a comparison of electron–proton and electron–deuteron scattering. The charge core of the neutron appears to be zero at low momentum transfers although a value of 30 per cent of that for the proton at large momentum transfers is not ruled out by the limits of accuracy of the measurements. The different charge radii for the neutron and proton raise the question whether charge symmetry holds or whether the interpretation of the results based on quantum electrodynamics is correct. A word of caution was given by Hofstadter against reading too much into the results until the accuracy is improved, but nevertheless the theoretical interpretation is in a very confused state.

Experiments with muons which can be compared with similar scattering experiments with electrons may be expected to shed more light on the structure of the nucleon during the next few years. The plea for some experimental information on the electromagnetic structure of the pion may have to wait a little longer.

In the two sessions devoted to the nucleon and its interaction with pions, photons, nucleons and antinucleons, some uncertainties which existed at the 1957 Conference in Rochester appear to have been satisfactorily resolved. In 1957 there was evidence that the coupling constant, f^2, obtained from the real part of the forward-scattering amplitude for negative pions via the dispersion relation was very low. However, new measurements of the negative pion–proton scattering cross-section have been made which bring the calculated value of f^2 into line with other determinations. A final value of $f^2 = 0\cdot0885 \pm 0\cdot002$ was quoted. The experimental and theoretical values for the 'Panofsky ratio' are now also believed to be in good agreement although this was only clarified after considerable discussion. Evidence for the Fermi set of phase shifts is also now well established. An excellent review of the theoretical position was given by Chew. The subject of greatest interest during the past year has been the dispersion relations and the possibility of their violation. However, the theoretical studies that have been made confirmed the belief that the Goldberger relations for forward scattering have a very general basis. Another development was a new type of dispersion relation which allowed a precise determination of the pion coupling constant. A basic question which continues to be obscure is whether it is possible in terms of the pion and nucleon masses and the coupling constant to predict the position of the (3/2, 3/2)-resonance and the small size of the non-charge-exchange S-wave scattering. In the GeV.-region, optical models of the pion-scattering results suggest that the pion–pion interaction is important.

The dispersion relation approach has also been applied to the problem of photon–nucleon scattering and the agreement of theory with experiment is improving. A great deal of discussion centred on the results obtained at Cornell and the California Institute of Technology, where photo-production processes appeared to show a resonance behaviour corresponding to excited states of the nucleon at 300, 600 and 1,000 MeV. The discussion was not conclusive.

There was also much discussion on the possible origin of the spin-orbit interaction introduced into the phenomenological nuclear potential by Gammel and Thaler and by Marshak and Signell last year. The large antinucleon–nucleon total cross-sections have, in fact, now been reasonably explained using a Signell and Marshak type of potential, and although this is again a purely phenomenological approach the feeling has subsided that the large experimental values for the antinucleon–nucleon cross-section would require a major departure from the Yukawa picture.

It is almost traditional now for the discovery of yet another new particle to be announced at the annual conference. This year the anti-Λ^0-particle was reported to have been observed in a two-prong-star event at Berkeley, decaying via a positive pion and antiproton, with a Q value of $35 \, {}^{+2\cdot6}_{-0\cdot9}$ MeV. In addition, a cosmic-ray event in a two-level cloud chamber belonging to the Pic du Midi group of the École Polytechnique has provided evidence for the cascade Ξ^0-particle. During the past year, six groups have been doing experiments to establish evidence for the particle of 500 electron masses which was first reported by Alikhanian some years ago. The general conclusion was that its existence was not yet firmly established. More experiments are still being carried out.

In the production of the Λ^0-particle in the pion–nucleon interaction, within the limited accuracy of the measurements, parity is conserved. Existing data are also in agreement with the conservation of isotopic spin. The interaction of K-mesons is explained most reasonably by a pseudo-scalar meson of spin zero. Below 100 MeV. in K^- interactions there is no evidence for anything other than S-waves being important.

One session was devoted to special topics, of which the most interesting related to the origin of the mass of the electron and whether it was entirely electromagnetic or not. An associated problem was the question of the large mass of the muon. It was suggested that a precise measurement of the magnetic moment of the muon would be of great value in order to check whether there was any departure from the value predicted by electromagnetic theory.

Perhaps the most remarkable achievement of the year has been the effort that has gone into the study of parity non-conservation in weak interactions. The two-component neutrino theory[*] is now well established. Parity non-conservation appears to be complete and no deviation from invariance under time reversal is observed. There are, however, some points which are not clearly understood. For example, non-conservation of parity is observed in hyperon decay where no neutrino is involved. The magnitude of the $\pi \rightarrow e + \nu$ and $\pi \rightarrow \mu + \nu$ branching ratio provoked much discussion, and it was emphasized that this could prove a very critical test of the universal Fermi interaction. The interaction is now well established as '$V - A$' (vector, axial vector) but the reason why it should be so is still unknown. The beta-decay of the Λ-particle is another puzzle. The present experimental results set the limit for this mode of decay at not more than 1 in 1,000 and they are, in fact, consistent with zero. A new value for the Michel parameter, $\rho = 0{\cdot}735 \pm 0{\cdot}022$, was reported from Berkeley in better agreement with that expected theoretically (0·75). However, the errors quoted are purely statistical and when systematic errors are allowed for, this value may again be changed.

In the case of non-leptonic modes the bulk of the new information concerned the decay modes and the branching ratios for Λ^0 and K^0 and the life-times of Λ^0, K^0 and $\Sigma^\pm$. From a study of the angular distribution of the decay with respect to the production direction it appears possible to assign to both the Λ^0 and Σ^- particles a spin of one-half. One new experimental technique, the scintillation chamber, was discussed at a small separate session. It may prove to be a useful new development.

The organizers at C.E.R.N. are to be congratulated on their efficient handling of the conference. The discussions were recorded on tape, typed and in the hands of those concerned for correction within twenty-four hours. The full proceedings of the conference including the talks by the rapporteurs are expected to be available to the participants by October.

G. H. STAFFORD

NEWS and VIEWS

Entomology and Parasitology at Liverpool : Prof. R. M. Gordon

PROF. R. M. GORDON, who is to retire from the Dutton and Walter Myers chair of entomology and parasitology in the University of Liverpool, acquired an interest in parasitic and arthropod-borne diseases during his army service in Serbia after his qualification at Trinity College, Dublin. Joining the staff of the Liverpool School of Tropical Medicine, he worked in the School's laboratories on the Amazon and in Sierra Leone. He relinquished the directorship of the latter laboratory in 1937 to occupy the chair in entomology in Liverpool; later the chair in parasitology was amalgamated with this. For the past twenty years, in spite of heavy teaching and administrative duties, Prof. Gordon has continued to engage in active research. Primarily a naturalist, not a systematist, he has maintained a 'zoo' of living parasites and their vectors rather than a collection of 'specimens' in his department. Many workers have achieved distinction following the sound training and wide practical experience gained in his department. Early in his career Dr. Gordon, with D. B. Blacklock, first demonstrated immunity to metazoan parasites. The meticulous detail of his work is to be seen in some remarkable micro-cinematograph recordings of the penetration of the mouth-parts of blood-sucking arthropods and their feeding methods. Latterly, the filarial infections have claimed his attention; he largely has originated and directed the helminthiasis research units now working on this problem in West Africa. Prof. Gordon's achievements have entailed much work on committees, which he serves wholeheartedly. The Royal Society of Tropical Medicine and Hygiene conferred its Chalmers Medal on him in 1937; recently it made him its president.

Dr. W. E. Kershaw

DR. W. E. KERSHAW, who is to succeed Prof. R. M. Gordon, joined the staff of the Liverpool School of Tropical Medicine in 1945 as a lecturer in parasitology. He served afloat, and later as a pathologist ashore, with the Royal Navy during the Second World War, and while stationed in Ceylon his contact with the parasitic infections of man determined his future interests. Dr. Kershaw's interests have primarily centred on the helminthiases, and in particular the filariases. His work on the latter has been original and outstanding, and he has travelled widely on field studies in this context. In 1955 he was awarded the Chalmers Medal of the Royal Society of Tropical Medicine particularly for his work in this subject, and his services are in frequent demand at conferences on it in Great Britain and elsewhere. Dr. Kershaw continues an active association with the Navy as a surgeon-commander, an activity which affords opportunity for a more clinical application of his abilities, and which should be of benefit to the Service to which he is proud to belong.

Geology at Southampton : Dr. F. Hodson

DR. F. HODSON's appointment to the newly created chair of geology at Southampton will give pleasure to geologists at home and abroad, particularly the younger generation. Trained in geology at the University of Reading, Dr. Hodson had the advantage (many forward-seeing geologists would say a necessity) of coming to the subject from two basic sciences. Initially a works chemist and by inclination a zoologist, he was well equipped to profit from university life and ultimately to undertake those researches in Namurian stratigraphy and palæontology for which he has become widely known. His work has shed new light on the Upper Carboniferous rocks of several key areas in western Europe: particularly western Eire, Belgium and the Valenciennes coalfield. In collaboration he has contributed to Jurassic stratigraphy and palæontology. At Reading Dr. Hodson has built up a flourishing Carboniferous research school, devoted mainly to opening up the exciting territory of western Eire. He will take to Southampton not only a tremendous enthusiasm and deep conviction that the 'research outlook' should dominate undergraduate teaching, but also an all-round fitness to foster the several facets of geology and to maintain a sensible balance between competing interests. The University of Southampton may confidently look forward to the future growth and vigour of its Geology Department, and to whole-hearted participation by its first professor of geology in the progress of this new seat of learning.

Applied Mathematics at Aberystwyth : Prof. T. V. Davies

Thomas Vivian Davies, since 1954 reader in mathematics at King's College, London, has been appointed to the chair of applied mathematics at University College, Aberystwyth, in succession to Prof. G. J. Kynch (see *Nature*, 180, 69 ; 1957). He received his undergraduate training in mathematics under Prof. V. C. Morton and the late Prof. T. Lewis at Aberystwyth, specializing already at that stage in fluid dynamics. During the War he worked with the Ministry of Supply and the Meteorological Office; since 1946 he has been on the staff of the Department of Mathematics at King's College, London. He went to the United States to carry out meteorological research in 1951, first at the Institute for Advanced Studies at Princeton and later at the Massachusetts Institute of Technology. Mr. Davies has been stimulated principally by geophysical problems : he has developed a new theory of gravity waves of finite amplitude, and has investigated the forced fluid motion and the stability of rotating liquids which are subject to differential heating. More recently, his work has been in the field of magnetohydrodynamics, and in pure mathematics his interests centre on non-linear differential equations. Mr. Davies has served as a member of the Council of the Royal Meteorological Society and of the Meteorological Research Council. His colleagues at King's College, London, have increasingly learned to respect him for his outstanding gifts as a teacher, for his no less inspired success as an originator and director of research in fluid dynamics and, by no means least, for his unassuming friendliness, his quiet efficiency and his other excellent personal qualities. In common with his many other friends, they wish him well in his new sphere of responsibility.

Pure Mathematics at Birmingham : Prof. P. J. Hilton

Dr. P. J. Hilton, who has recently been appointed Mason professor of pure mathematics in the University of Birmingham, in succession to Prof. C. A. Rogers (see *Nature*, 181, 1378 ; 1958), is a graduate of Oxford, where he was a scholar of Balliol College. After taking his degree in 1947 he held lectureships in the Universities of Manchester and Cambridge until he returned as senior lecturer to Manchester in 1955. His research interests have always been in topology, more particularly in homotopy theory, and its recent developments by the methods of homological algebra : he is the author of a Cambridge Mathematical Tract on homotopy. Dr. Hilton has many contacts with European universities, and was appointed by the Royal Society as delegate to the recent mathematical congress in Roumania. He has shown by his talks to radio and other audiences his interest in all sides of the problems of university teaching, and both he and the University of Birmingham are to be congratulated on this appointment.

Foreign Members of the Academy of Sciences of the U.S.S.R.

At a general session on June 20 the following were elected foreign members of the Academy of Sciences of the U.S.S.R. : *Belgium*, Prof. Z. M. Bacq (biology) ; *Bulgaria*, Prof. G. Nadzhakov (physics and mathematics) ; *Canada*, Prof. E. Steacie (chemistry), Prof. W. Penfield (neurophysiology) ; *China*, Prof. Lee Ssu-Kwang (geology and geography), Prof. Kuo Mo-Zso (history) ; *Korea*, Prof. Pek Nam Yu (history) ; *Czechoslovakia*, Prof. F. Šorm (chemistry) ; *Denmark*, Prof. K. V. Linderstrøm-Lang (biology) ; *France*, Prof. Louis de Broglie (physics), Prof. Louis Néel (physics) ; *German Democratic Republic*, Prof. G. Hertz (physics), Prof. M. Volmer (chemistry) ; *Great Britain*, Prof. J. D. Bernal (physics), Sir Cyril Hinshelwood (chemistry), Prof. C. F. Powell (physics) ; *Hungary*, Prof. I. Rusznyak (biology) ; *India*, Prof. P. C. Mahalanobis (statistics and economics) ; *Italy*, Prof. E. Amaldi (physics), Prof. B. R. Bandinelli (history) ; *Japan*, Prof. S. Kaya (physics) ; *Poland*, Prof. T. Kotarbinski (philosophy) ; *Roumania*, Prof. T. Savulescu (biology) ; *Sweden*, Prof. H. Alfvén (physics), Prof. K. M. B. Siegbahn (physics) ; *Switzerland*, Prof. L. Ruzicka (chemistry) ; *United Arab Republic*, Prof. A. R. Tourky (chemistry), Prof. I. Khalil (literature) ; *United States*, Prof. L. Pauling (chemistry), Dr. D. Bronk (biology) ; *Yugoslavia*, Prof. P. Savić (chemistry).

Royal Society Research Studentships

The Council of the Royal Society has awarded Mr. and Mrs. John Jaffé Donation Studentships in original scientific research from October 1 to Dr. E. A. Magnusson to continue his study of the modification of atomic orbitals in bond formation in the Department of Chemistry, University College, London, and to Dr. Jennifer Wildy to work on the biosynthesis of the protein and hæm components of hæmoglobin in the Department of Chemical Pathology, University College Hospital Medical School.

Nutrition Society of Canada

A meeting of persons interested in nutrition research was held in Ottawa on October 7, 1957, to discuss the formation of a nutrition society. A provisional committee was appointed to prepare a list of founding members and to draft a constitution. On June 8 a formal meeting took place in Queen's University, Kingston, Ontario. A membership of ninety was accepted, a constitution adopted, and the society was named the Nutrition Society of Canada. Membership is restricted to persons concerned with the scientific aspects of nutrition. Officers of the Society are : *President*, E. W. McHenry (Toronto) ; *Vice-President*, E. W. Crampton (Ste. Anne de Bellevue) ; *Secretary*, George H. Beaton (Toronto) ; *Treasurer*, J. A. Campbell (Ottawa) ; *Members of Council*, D. H. Copp (Vancouver), W. W. Hawkins (Halifax), L. B. Pett (Ottawa). The Society intends to hold annual meetings.

Aerial Geophysical Survey of Cornwall

In a written answer to a question on July 15 regarding the aerial geophysical survey of south-west Cornwall made last year for the Atomic Energy Authority, Mr. H. Nicholls, Parliamentary Secretary to the Ministry of Works, as representing the Lord President of the Council, said that the Department of Scientific and Industrial Research has recently published a brief description of this air-borne survey made by the radiometric method. A scientific appraisal of the work will be presented in a paper at the Second International Conference on the Peaceful Uses of Atomic Energy to be held at Geneva early in September and will be published in the Proceedings of the Conference. Ground investigations are continuing in Cornwall and it will be some time before all data recorded from the air have been assessed.

Design in Industry

MANY interesting suggestions concerning the education and training of designers for the furniture, pottery, printing and textile industries are contained in "The Training of Designers for Industry" (pp. vii+50. Federation of British Industries, 21 Tothill Street, London, S.W.1, 1957. 3*s*. 6*d*.). This is the report of a one-day conference between industrialists and educationists, organized under the auspices of the Federation of British Industries and held in London on September 24, 1957. The booklet includes the opening address by Sir Edward Boyle, Parliamentary Secretary to the Ministry of Education, and reports by the chairmen of the five discussion groups on important points made in the course of the conference, together with a summing-up by Sir Ernest Goodale, chairman of the Federation's Industrial Art Committee. It also includes the memoranda circulated before the conference as bases for the group discussions.

National Science Foundation Programme for Atmospheric Sciences

AN Atmospheric Sciences Programme is being established by the U.S. National Science Foundation as a result of recommendations by the President's Committee on Weather Control and the Committee on Meteorology of the National Academy of Sciences —National Research Council. The new programme will deal with meteorology, including not only the more conventional type of meteorological research, but also energy transfer processes between earth, sea and air; turbulent flow of gaseous fluids; heat exchange processes; upper atmosphere studies (that is, above the level of conventional meteorological work); atmospheric chemistry; and general circulation problems of the atmosphere and oceans. Attention will also be given to the field of cloud physics, especially the physics of precipitation, where much basic research must be pursued before the possibilities of controlling or modifying weather can be evaluated. The programme director will be Dr. Earl G. Droessler, who has wide experience in administration and co-ordination of military scientific research and development, and in research in meteorology and glaciology.

Agricultural Meteorology in India

A SPECIAL issue of the *Indian Journal of Meteorology and Geophysics* was published in December 1957 in honour of the silver jubilee of the Agricultural Meteorology Division of the India Meteorology Department. The importance of the scientific study of the relations between crops and weather has long been recognized, notably early in this century in Britain by Sir Napier Shaw, and the International Meteorological Organization formed its Commission for Agricultural Meteorology in 1913. It is, however, only in relatively recent years that stations specifically equipped and staffed by meteorological physicists have been set up to make detailed micrometeorological and related observations. India, under Sir Charles Normand's tenure of the post of Director-General of Observatories, was one of the first countries to establish such a unit. The Division was formed at Poona in 1932 and placed under Dr. L. A. Ramdas, who remained in charge until 1953.

The Central Agricultural Meteorological Observatory is on the farm of the Agricultural College at Poona. It is equipped with instruments for observing the micro-structure of the atmosphere up to 35 ft. in the free air and within crops, and also radiation, evaporation, soil properties and plant temperatures. The Division also controls less detailed meteorological work at some forty other experimental farms in India, and maintains weekly charts of the relevant weather elements and of the progress of crops all over India. The major work now in progress is concerned with the water requirements of plants, the relation between weather and the incidence of disease and pests and the preparation of crop–weather calendars for the guidance of regional meteorological centres in the preparation of the weather forecasts for the farmers' weather bulletins. It was at this Division that the observation was first made that under clear sky at night the air just above ground is often colder at a height of 5–15 cm. than at the ground itself. This observation, scarcely credited for a time, has been repeated at several places elsewhere with other types of apparatus but is still not fully explained.

University College, London: Report for 1956–57

THE annual report of University College, London, for 1956–57 (pp. 89. London: University College, 1958) includes the report of the chairman of the College Committee and the provost, together with those of the Students' Union, the Bartlett School of Agriculture and the Slade School of Fine Art, and lists of publications of members of academic departments. Of the 3,574 students (including 795 part-time) 755 were postgraduate (239 part-time). Some 589 undergraduates and 318 postgraduates were in the faculty of science and 206 undergraduates and 66 postgraduates in engineering. The year was the last of the old quinquennium, which closed with a deficit of £2,455, and the report, commenting on the absence of general funds for research, records the severe disappointment with the grant from the University Grants Committee for the new quinquennium: that of £1,165,000 for 1957–58 will permit no academic expansion and will necessitate a substantial cut in maintenance. Capital expenditure of £280,000 was concentrated on the new Biological Sciences Block, but the planning of the first stage, to cost £500,000, of the new Engineering Building is well advanced. In the Department of Chemistry investigations of the mechanisms of reactions in solution have recently been correlated with studies of reactions in the gas phase, and some main lines of investigation have been greatly facilitated by the installation of a nuclear magnetic resonance apparatus through the generosity of the Wellcome Trust. In the Department of Physics assembly of the microtron has proceeded satisfactorily (see *Nature*, June 21, p. 1726), and the new high-pressure cloud chamber has been assembled and tested.

Arthur D. Little Research Institute

THE first annual report of the Arthur D. Little Research Institute (Inveresk, Midlothian), inaugurated on March 22, 1957, records that on December 31 the Institute's staff totalled twenty-two, of whom twelve were qualified scientists. The three projects under investigation at that date embraced a general study of linear polymers of spatially regular structures, including the mechanism and kinetics of formation of such polymers and their physical properties; a study of sucrose, starting with the sodium sucrates and their condensates with chloro compounds; and a corrosion project including an investigation of the effect of the structure of organic additives, with particular emphasis on physical and chemical inhibition mechanisms around the neutrality point. Five papers published during the year are listed, as well as the titles of six others submitted for publication.

Climatic Tables

The Meteorological Office receives a very large number of inquiries for climatic data for places in all parts of the world from industrial firms and others. Many of these inquiries relate to temperature, humidity and precipitation and it has been the practice to prepare and sell mimeographed tables of these elements to inquirers. The data most required are now being published (Air Ministry: Meteorological Office. Tables of Temperature, Relative Humidity and Precipitation for the World. London: H.M. Stationery Office, 1958) in six parts as follows: (1) North America, Greenland and the North Pacific Ocean; (2) Central and South America, the West Indies and Bermuda (to be published shortly); (3) Europe and the Atlantic Ocean north of 35° N. (to be published shortly); (4) Africa, the Atlantic Ocean south of 35° N., and the Indian Ocean; (5) Asia; (6) Australia and the South Pacific, Antarctica. Each part gives monthly values of the following information for a carefully selected and representative set of several hundred observing stations: temperature: average daily maximum and minimum, average highest and average lowest in each month, absolute maxima and minima; relative humidity: average values, varying times but selected as far as possible to give night and midday values; precipitation: average monthly fall, maximum in 24 hr., average number of days of 0·01 in. or more. Each part has a map showing the stations, an index, and bibliography of sources, and the latitude, longitude and height of each station is given in the tables. Great care has been taken in collaboration with the British Government's Permanent Committee on Geographical Names to give place-names under all the forms by which each is likely to be known, a matter of no small difficulty for places in the Far East and U.S.S.R. All six volumes are also being made available bound into one book.

The Absorption Spectrum of Water Vapour

In his paper, "Das Spektrum des Wasserdampfes" (*Ber. Deutsch. Wetterdienstes*, Nr. 44, 6; 1958), W. Regula gives a valuable summary of the theory of, and experimental information on, the absorption spectrum of water vapour over the wave-length range 1·35 cm. to 300 A. The positions of the absorption bands are given in tables under the type of process responsible. The intensities are indicated qualitatively (strong, medium, weak) in most instances. The paper may be useful to physicists as well as meteorologists.

Spectrum of the Night Sky

In a paper on the altitude of atmospheric layers emitting the lines [O I] 5577 A., [O I] 6300 A. and [Na I] 5892 A. (*Pub. de l'Observ. de Haute-Provence*, 3, No. 36; 1957), Jean Dufay and Tcheng Mao-Lin have re-examined all the observations of the bright lines in the night-sky spectrum. Following the method described by Barbier, corrections for extinction and for scattered light have been made. Taking into account only the molecular scattering and the absorption by atmospheric ozone, the following equivalent heights are obtained: λ, 5577 A., *z*, 195 km.; λ, 5892 A., *z*, 200 (or 230) km.; λ, 6300 A., *z*, 280 km. If, however, a thin layer of haze is present in the lower atmosphere, producing at the zenith the additional optical density $D_0(v) = 0{\cdot}0050$, these heights may be reduced to 170, 170 (or 200) and 250 km., respectively. The uncertainty arising from a selective absorption by water vapour and by oxygen molecules, chiefly from the emission of the OH band, is also discussed.

Cricket Bat Willow

Salix alba var. *caerulea* is as a timber tree unique in Britain, in that the care lavished on it during (and after) its lifetime is reminiscent more of the practices of horticulture than of forestry. This is the result of the high value of its timber when well grown. Current methods of producing timber of the best quality are fully described in "Cultivation of the Cricket Bat Willow" (Forestry Commission. Bulletin No. 17. Pp. vi+34+33 plates. London: H.M. Stationery Office, 1958. 5*s*. net). Rooted or unrooted 'sets' (cuttings) are planted widely (at least 30 ft. apart), lateral branches are removed early and buds appearing on the main stem are rubbed out before they become woody, to a height of 8 ft. Thus a mature stem 8 ft. long and free of knots is produced, but even so, only the lower part of the trunk may give timber suitable for cricket bats of the highest quality. Rapid growth gives the desired sapwood (heart wood is not used in bat making) with annual rings up to 1 in. in width, and this with a straight grain combined with toughness and ability to withstand compression are all characters looked for in the timber by the bat maker. It is now known that male as well as female trees may combine all these desirable qualities in their wood, but they will be lacking unless the site is carefully chosen, insect pests controlled, and protection from grazing animals afforded, and even then 'stain' may develop in the timber, or water-mark disease (due to *Bacterium salicis* Day) affect the trees, rendering them virtually useless.

Control of Aquatic Weeds

Progress in the control of weeds on agricultural land has not been paralleled by the evolution of reliable methods for the control of aquatic weeds. Present-day practices and the results of recent research in this field are summarized by Aylwin P. Chancellor in "The Control of Aquatic Weeds and Algae" (pp. 20. London: H.M. Stationery Office, 1958. 2*s*. 6*d*. net). Mechanical methods of removing weeds from ponds and lakes are often preferable to chemical means, but for emergent weeds in still or running water the use of growth substances (particularly sodium 2 : 2-dichloropropionate) offers great promise. Sodium arsenite can be used to control submerged weeds in still water and is effective at concentrations that are harmless to fish. Submerged weeds in running water cannot be satisfactorily controlled, while chlorine and copper sulphate, both effective in controlling algae, have the disadvantage of extremely high toxicity to fish. Added to this is the fact that if a heavy growth of algae is killed off, the products of decay and the great reduction in the oxygen content of the water may be undesirable. Treatment in spring or early summer may kill the pioneers of the algal flush of growth so that control without any secondary ill-effect is secured.

American experiments indicate that the concentration of copper sulphate necessary to control some algae (for example, 5·0–10·0 p.p.m. for *Scenedesmus*) may greatly exceed the limits tolerated by fish. Trout, for example, in River Itchin water containing 1 p.p.m. of copper sulphate were killed within 24 hr. Chlorine has similar disadvantages, but rosin amine compounds and 2 : 3-dichloronaphthoquinone both have promise as algicides.

Zoological Nomenclature

THE International Commission on Zoological Nomenclature gives notice that, as from December 6, it will start voting on the following cases involving the possible use of its plenary powers for the purpose specified against each entry. Full details of these cases were published on June 6 in the *Bulletin of Zoological Nomenclature* (16, Part 2) : *Mysis* Latreille [1802–1803], designation of type species for, and validation of neotype for species (*Cancer oculatus* Fabricius, 1780) so designated (Cl. Crustacea, Order Mysidacea) ; (2) *Dactylioceras* Hyatt, 1867, designation of type species for (Cl. Cephalopoda, Order Ammonoidea : Jurassic) ; (3) *gemmascens* Esper [1794] (*Madrepora*), validation of (Cl. Hydrozoa, Order Stylasterina). Comments should be sent as soon as possible in duplicate to R. V. Melville, assistant secretary to the Commission, 28 Park Village East, Regent's Park, London, N.W.1.

A Kerr Cell Electro-Optical Shutter

AN exposure time of 0·01 μsec. is claimed for the Kerr cell electro-optical shutter and improved pulse-generator circuit devised by Avco Manufacturing Corporation's Research and Advanced Development Division (Lawrence, Massachusetts). The cell is of 2 in. square cross-section, and the electric field needed to produce phase rotation of the electromagnetic vector as it passes through a cell filled with nitrobenzene is 10–15 kV./cm., so that for a 5-cm. aperture the pulse generator must deliver a pulse of 50–75 kV. to the Kerr cell plates. The generator consists of a coaxial cable and a spark gap, and the cell is connected directly across the load resistor on the transmission line. Exposure time can be varied accurately from 0·01 to 0·1 μsec. by changing the length of the transmission line. The form of the exposure characteristic is approximately square-wave. The selective absorption polarizing material used for the polarizer and analyser on the cell does not provide a completely opaque shutter in the 'off' position, but a transmission ratio of about 20,000 to 1 is obtained with ordinary stock material. The angle of incident light must be limited to 10 deg. or less from the normal, providing a limiting aperture of about *f*/2·5 and an effective aperture of about *f*/10 in operation of the shutter.

Geochemistry

CERTAIN aspects of migration of the chemical elements in the Earth's crust during geological times are discussed by A. A. Saukov (*Priroda*, 2, 10 ; 1958). While the majority of migration processes may be considered to be of a non-directional character, certain processes may give rise to directional types of migration. Thus, the gradual diminution of the quantities of radioactive elements in the Earth and a consequent diminution of the thermal energy of radioactive source may have affected the intensity of metamorphism and magmatism during the geological history. Also, one may consider that the emergence and development of the biosphere has greatly affected the nature and the intensity of migration of the elements, which not only determine the 'directed' accumulation of such organogenic deposits as, for example, coal, bitumen and limestone, but also lead to the accumulation of free oxygen in the atmosphere. This, in its turn, may have affected the behaviour of iron compounds present in the hydrosphere, by a widespread precipitation of the oxidized ferric forms, so prevalent in the widespread iron ore deposits formed in the Pre-Cambrian metamorphic rocks.

National Science Foundation Grants for Science

THE National Science Foundation awarded 246 grants totalling 4,720,545 dollars during the quarter ending March 31, 1958, for the support of basic research in the sciences, for conferences in support of science, for exchange of scientific information, for short-term research by medical students, and for training of science teachers. This is the third group of awards to be made during the current fiscal year. During the first two quarters, awards totalled almost 20·5 million dollars. The research fields included are astronomy, chemistry, biology, physics, earth sciences, engineering sciences, mathematical sciences and social sciences.

Society for Applied Bacteriology

AT the recent annual meeting and summer conference of the Society for Applied Bacteriology, held in Bristol, the following officers of the Society were elected : *President*, Mr. D. A. McKenzie ; *Hon. Secretary*, Mr. G. Sykes (Boots Pure Drug Co., Ltd., Microbiology Division, Standards Department, Nottingham) ; *Hon. Treasurer*, Mr. G. Elis Jones ; *Editor-in-Chief*, Dr. S. E. Jacobs ; *Editor*, Dr. C. A. E. Briggs ; *Hon. Publications Manager*, Mr. A. H. Walters ; *Hon. Advertising Manager*, Mr. E. J. Mann ; *Committee*, Dr. Eve Billing, Mr. N. J. Butler, Prof. E. L. Crossley, Dr. J. G. Davis, Dr. N. R. Knowles, Dr. Jane Meiklejohn, Mr. C. A. Scarlett, and Dr. M. Woodbine.

Darwinism and the Study of Society

To mark the centenary of "The Origin of Species", a conference, organized by the Social Sciences Research Centre of the University of Edinburgh, will be held in Adam House, Edinburgh, during April 8–10, 1959. The proceedings will be divided into six sessions, as follows : (1) "Darwin's Place in the History of Thought", Prof. B. Willey (Cambridge), "The Intellectual Background during Darwin's Student Years in Edinburgh", Mr. G. A. Shepperson (Edinburgh) ; (2) "Darwinism and Human Society in Retrospect", Prof. Lancelot Hogben (Birmingham), "Natural and Social Selection", Dr. W. Stark (Manchester) ; (3) "Genetic Determinants of Human Behaviour", Prof. C. H. Waddington (Edinburgh) ; (4) "Social Evolution", Prof. Morris Ginsberg (London) ; (5) "Communication in Animal and Human Societies", Mr. S. A. Barnett (Glasgow) ; (6) an appraisal of the conference by Dr. J. Bronowski (director of the Coal Research Establishment) and Prof. Asa Briggs (Leeds). Further particulars may be obtained from Dr. M. P. Banton, 39 George Square, Edinburgh 8. Limited accommodation for visitors will be available in one of the University halls of residence ; early application is advised.

International Symposium on Combustion

The seventh International Symposium of the Combustion Institute will be held during August 28–September 3, under the auspices of the British Section of the Institute and the Institute of Fuel, 18 Devonshire Street, London, W.1. It is the first occasion on which the Symposium has been held outside the United States. Participants are attending from more than fifteen different countries. Dr. Bernard Lewis, president of the Combustion Institute, Dr. von Kármán, and many others will attend from the United States, and Academician N. N. Semenov will be among those from the U.S.S.R. Participants are expected to register at the Institute of Fuel on August 27. There will be a reception for those coming from overseas on that evening, given by Her Majesty's Government at Lancaster House. The opening meeting will be held on August 28 at the Royal Institution, Albemarle Street, at 10 a.m. There will also be a visit to the Laboratories of Combustion Research at the Imperial College of Science and Technology and a dinner at the Guildhall that evening, at which Lord Brabazon will be the chief guest. The rest of the proceedings will be held in Oxford, during August 29–September 3, when about a hundred papers (preprinted and circulated) will be discussed in fourteen separate sessions, only four of which will overlap.

University News : London

The following appointments in the University of London have recently been announced: Dr. D. Gabor, Mullard reader in electronics at the Imperial College of Science and Technology, to the University chair of applied electron physics at that College; Prof. L. J. Lewis, B.Sc. (Wales), former director of the University College of Ghana Institute of Education, to the University chair of education, with special reference to education in tropical areas, at the Institute of Education; Dr. J. Sutton, reader in geology, to the University chair of geology, and Dr. R. D'A. Hoyle, senior lecturer in mechanical engineering, to the University readership in mechanical engineering, both at the Imperial College of Science and Technology; Dr. W. J. H. Butterfield, to the University chair of experimental medicine at Guy's Hospital Medical School.

The title of professor in the University has been conferred on the following in respect of their posts at the Colleges and Schools indicated: Dr. R. S. Stacey (pharmacology and therapeutics in St. Thomas's Hospital Medical School); Dr. Eleanor J. Zaimis (pharmacology in the Royal Free Hospital School of Medicine).

The title of reader in the University has been conferred on the following: Mrs. J. E. Floud (sociology of education in the Institute of Education); Dr. R. J. Harrison-Church (geography in the London School of Economics and Political Science); Mr. O. R. McGregor (social institutions in Bedford College).

The title of professor emeritus has been conferred on the following, on their retirement from chairs at the Colleges and Schools indicated: Prof. W. N. Bailey (mathematics at Bedford College); Prof. K. J. Franklin (physiology at St. Bartholomew's Hospital Medical College); Prof. F. M. Haines (botany at Queen Mary College); Prof. L. Dudley Stamp (social geography at the London School of Economics and Political Science).

Dr. A. R. Fairbairn has been appointed to the General Motors Corporation of Detroit postdoctoral fellowship in flame spectroscopy, tenable at the Imperial College of Science and Technology.

Swansea

The following appointments have recently been made in the University College of Swansea: Dr. S. K. Zaremba, to be lecturer in the Department of Pure Mathematics; Dr. E. G. Brown, to be lecturer in the Department of Botany; Mr. J. D. Davies, to be lecturer in the Department of Engineering.

Announcements

The British Society of Rheology is organizing a conference on "Rheology of Road Materials" to be held at the Road Research Laboratories, Harmondsworth, on October 24. Further information can be obtained from the Honorary Secretary, 52 Tavistock Road, Edgware, Middlesex.

The second International Congress of Speleology will be held at Bari, Lecce and Salerno in Italy during October 5–12. Further information can be obtained from the secretary-general of the Congress, Prof. Franco Anelli, Castellana-Grotte, Bari, Italy.

The International Association of Allergology is holding the third International Congress of Allergology in Paris at the New Medical School during October 19–26. Further information can be obtained from the secretary, B. N. Halpern, 197 Boulevard St. Germain, Paris, 7e.

The next standard course at the Harwell Reactor School on which places are available starts on November 10, and ends on March 6, 1959. The fee for the course is £250 exclusive of accommodation. Applications will be considered from overseas as well as the United Kingdom. Forms and further information can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

The Foundations' Fund for Research in Psychiatry announces that October 15 is the latest date for the submission of completed applications for research fellowships in psychiatry, psychology, sociology, neurophysiology, and other sciences relevant to mental health. The latest date for applications for research grants-in-aid is December 10. Further details can be obtained from the Foundations' Fund for Research in Psychiatry, 251 Edwards Street, New Haven 11, Connecticut.

The Research Fund of the Chemical Society provides grants for the assistance of research in all branches of chemistry. About £700 per annum is available for this purpose. Applications for grants will be considered in November next and should be submitted on the appropriate form not later than November 14. Applications from Fellows will receive prior consideration. Further information can be obtained from the General Secretary, The Chemical Society, Burlington House, Piccadilly, London, W.1.

Erratum. Mr. M. J. Lyons has written referring to his communication entitled "Presence of 1,2,3,4-Dibenzopyrene in Cigarette Smoke" in *Nature*, of July 19, p. 178, stating that the first sentence of paragraph 4 should read: "Small quantities of 1,2,3,4-dibenzopyrene have been detected in the exhaust products from petrol and Diesel engines".

PROGRESS IN CANCER RESEARCH

THE Seventh International Cancer Congress, organized by the International Union against Cancer, was held in London during July 6–12 under the presidency of Sir Stanford Cade. A meeting involving about 600 papers and 2,500 members is not easy to survey: as was to be expected, nothing dramatic emerged and in these circumstances it is almost impossible to judge where the most significant advances are in fact being made. Specialists in the many disciplines embraced by cancer research would all have differing ideas on this, and a short review of the proceedings must therefore be a biased one.

Hormones

O. Mülhbock (Holland) expressed the view that cancer induced by hormones is always the result of super-normal production of a growth-stimulating hormone and that hormonal deficiency never gives rise to neoplasia. Mülhbock and his co-workers have shown that breast carcinoma can be induced in mice free from the milk factor by the repeated implantation of pituitary glands from mice of the same strain. A. Lipschutz (Chile) described the occurrence of an ovarian neoplasm (luteoma) following sub-total castration. This is possibly another instance of pituitary over-stimulation. R. E. Kavetsky and his colleagues (U.S.S.R.) provided evidence that disturbance of the rhythm of activity of the pituitary gonadotropic and mammatropic hormones was a feature of high-cancer strains of mice. Another example is that described by J. Bielschowsky (New Zealand) in the case of thyroid tumours, the genesis of which is dependent on continuous over-stimulation by the pituitary thyrotropic hormone. The tumour itself may continue to be dependent on the same hormonal stimulation. This property has been utilized in treatment in man, since by administering a goitrogen the tumour can be induced to secrete thyroxin and thus become vulnerable to radioactive iodine.

One has the general impression that the relation between hormonal stimulation and cancer is being clarified rapidly and its role in the genesis of human tumours, particular of the breast, may prove important. The mechanism is still little understood, but the knowledge that certain tumours of tissues responsive to sex-hormones may still be dependent on such hormones has resulted in a significant therapeutic advance. C. Huggins (United States), who has notable achievements in this field to his credit, reviewed the treatment of cancer of the breast by surgical removal of the ovaries and the adrenal and pituitary glands. Both he and H. Shay (United States) described useful and rapid methods of inducing cancer in the breast of rats by intensive but limited oral treatment with methylcholanthrene.

Metabolism of Carcinogens

The fate of injected chemical carcinogens with its corollary, the mechanism of carcinogenesis, was a dominant topic. I. Berenblum (Israel) reviewed this subject and suggested that with the polycyclic hydrocarbons there is still no firm evidence on whether the carcinogen itself or a metabolite is the decisive factor. On the other hand, C. Heidelberger (United States) argued that carcinogenic activity is correlated directly with specific protein-binding as a first step leading eventually to the deletion of the essential enzymes regulating cell-growth. He gave evidence that the binding is in the *K* region first described by the Pullmans. A. Pullman (France) described his electronic theory and urged greater co-operation on the biological side which will be necessary to test its validity. The theory demands protein-binding with the carcinogen and not with a metabolite.

H. R. Gutmann (United States) showed that an *ortho*-hydroxyamine derivative from 2-acetylaminofluorene is capable of protein-binding in simple biochemical systems. Specific protein-binding as the primary process in carcinogenesis is an exceedingly important concept and, though not mentioned extensively at the Congress, its implications in the immunological approach to cancer were stressed by H. N. Green (Great Britain) and others.

The metabolism of the carcinogenic aromatic amines is largely linked up with studies on bladder cancer. G. M. Bonser (Great Britain) described the pioneer work by which she and her colleagues had shown that 2-naphthylamine is carcinogenic to the bladder of dog and man by virtue of its conversion to 2-amino-*l*-naphthol. The evidence that *ortho*-hydroxyamines are of importance in amine carcinogenesis in general was amplified by D. B. Clayson (Great Britain) and L. Bradshaw (Great Britain) in relation to the metabolic fate of benzidine and 4-aminodiphenyl.

E. Boyland (Great Britain) suggested that carcinogenic metabolites may be liberated in the bladder by the action on the *ortho*-amino phenol conjugates (formed in the liver) of the enzymes glucuronidase and phosphatase. He described carcinogenic *ortho*-aminophenols (for example, 3-hydroxyanthranilic acid) which are products of tryptophan metabolism and so may be endogenous carcinogens. Since urinary β-glucuronidase is inhibited by oral administration of 1 : 4-glucosaccharolactone, the possibility of preventing bladder cancer arises.

Ionizing Radiations

Interest in ionizing radiations was mainly focused on the carcinogenic hazard in man and the induction of tumours in mice. R. Doll (Great Britain) described the definite but low incidence of leukæmias induced by X-rays in man and the evidence supporting somatic mutation as the cause. A. M. Brues (United States) opposed this view, because the evidence also suggests that the risk of carcinogenesis increases disproportionately to the dosage.

One of the many interesting ways of inducing cancer by irradiation was described by P. Furth (United States) who, by irradiating the pituitary gland, produced tumours which were functional and thus induced tumours in other conditioned target organs. L. W. Law (United States) described malignant lymphomas in mice given homologous or semi-isologous bone marrow as a protection against lethal irradiation. H. S. Kaplan (United States) argued that carcinogenic agents may act indirectly since thymic leukæmias occur in the unirradiated thymus grafted into thymectomized mice subjected to prior irradiation. N. Petrov (U.S.S.R.) and his co-workers described the production of tumours in the bones of apes by the local action of radioactive minerals, an effect not obtained with carcinogenic hydrocarbons.

Viruses

Tumour viruses were widely discussed, but the outstanding interest was in the leukæmia viruses of mice. L. Gross (United States) discussed his work on the induction of leukæmia and parotid tumours with cell-free extracts of leukæmia tissues given to new-born mice. C. Friend (United States) described similar extracts rapidly inducing leukæmia in adult mice, while T. Latarjet (France) dealt with cell-free extracts —and deoxyribonucleic and ribonucleic acids derived from them—accelerating the onset of leukæmia and inducing the appearance of other tumours. These and other important contributions have great theoretical interest. Their relation to human leukæmias is doubtful, and indeed Sir Macfarlane Burnet rather disturbed the cancer virus experts by his categorical declaration on epidemiological grounds that viruses played no part in the etiology of solid tumours in man.

Immunology and Immunogenetics

There were signs of a mounting interest in the field of immunology and immunogenetics not only in the number of directly relevant papers submitted but also in the references to immunological approaches in many others. H. N. Green (Great Britain) described his immunological theory, which ascribes the neoplastic state to absence of tissue-specific immunological identity in the cell. Evidence was presented that a specific antigenic complex is formed by carcinogen binding probably with a lipo-protein complex which, possibly as a result of an immune reaction, results in the emergence of a strain of cells lacking such a complex. E. Weiler (United States) has previously found a loss of tissue-specific antigens in chemically induced tumours of the liver and kidney and, by ingenious isotopic and immune techniques, has now demonstrated their loss in the second generation of normal kidney epithelium tissue culture. The failure to induce chemical carcinogenesis, contrasted with the occurrence of malignant transformation in tissue culture, was one of the many facts presented originally in support of Green's theory. C. A. Zilber (U.S.S.R.), as well as G. P. Cunningham and his co-workers (Great Britain), indicated that an antigenic complex is formed in chemical carcinogenesis of the liver. Zilber found that this disappears, to be replaced in the tumour by a specific antigen with no carcinogen specificity. Tumour antigens are found in human and virus tumours. Antigenic change in tumours is both quantitative and qualitative.

Sir Macfarlane Burnet, in a broad survey of the biological nature of cancer, concluded that it can best be explained on a basis of somatic mutation and clone selection. The problem is to find whether these mutations are due to random action of many kinds of stimuli, deviation of some process of cellular differentiation or enforced and directed mutation by the action of specific substances. The auto-immune state is not excluded as a cause, but more experimental support is needed. G. Klein (Sweden) suggested that the evolution of the neoplastic cell towards greater autonomy is due to intercellular variation followed by selection. L. Sachs (Israel) demonstrated that though greater freedom of transplantability may involve loss of agglutinogens it always implies greater antigenicity in general, a finding which is by no means opposed to an immunological theory of loss of cytoplasmic specific antigens.

Immunological ideas are being increasingly used in experimental therapy, for example, in tagging radioiodine on to tissue-specific antibody globulin (by I. L. Spar and his co-workers in the United States).

Space does not allow of discussion of many important subjects. Naturally, the relation between smoking and cancer was a prominent topic, and half the Congress was devoted to clinical papers. These topics and the important subject of the control of cancer are of great importance, but they will be covered fully in the medical press. Chemotherapy, however, must be mentioned here, as it occupied an important part of the proceedings. Many new synthetic compounds were described, the present emphasis being away from the radiomimetic and towards the anti-metabolic compounds. Nevertheless a large amount of work still stems from the original work of A. Haddow and his colleagues on therapy with alkylating agents. Moreover, the great number of papers on nucleic acid metabolism and carcinogenesis reported at the Congress were derived largely from the original studies on the mechanism of action of such agents.

Even a long review could not be fair to every significant contribution. It is indeed very possible that among the hundreds not mentioned specifically some may have more potential importance than any cited here. For example, the work of K. Setälä and his co-workers (Finland) on the cancer-promoting activities of 'Tween 60' or of the purely physical induction of cancer by plastic films by E. T. Oppenheimer (United States) may fall within this category. The cancer scene still covers a broad canvas and the vitally important detail may not yet have been emphasized.

H. N. GREEN

BRITISH RAYON RESEARCH ASSOCIATION

OPEN DAYS

THE British Rayon Research Association held the third of its annual open days during May 7–9. The total attendance was 650–700, some 300 attending on the second day. A new technological building has been built and this houses the wool processing machinery, the work on vibration problems on spinning frames and the fluid-bed work. All the work of the Association was shown with the exception of that on fluid beds, which, as it has been moved twice in the past twelve months, was not in a suitable condition for demonstration. In order to present the fundamental work in a form which showed its relevance to problems in the textile industry, two short lectures on the work of the chemistry and physics groups were given by the senior chemist and senior physicist immediately after lunch on each day. These were well attended and well received.

Because of the disorganization caused to technological work by the vacation of the Barton Dock Road premises and the subsequent upheaval in the

Association when the additional technological building was brought into use, the different sections have been reduced in their activities for periods varying from two to three weeks to two to three months. This interruption to the work has been utilized to reconsider the machines which are required for future work and also to review the research programme. As a consequence the amount of new development which could be demonstrated was rather less than in previous years.

On the chemistry side, the work on the alkaline degradation of cellulose is being reviewed and the general picture of the mechanism of degradation has been modified to account for the presence of the large number of acidic products[1]. The study of the kinetics of the oxidation of model compounds, preparatory to a study of the oxidation of cellulose, has been continued. Even in the case of ethyl alcohol the mechanisms originally proposed have been shown not to be sufficient to account for all the kinetic results. Thus it is necessary to postulate a unimolecular decomposition of the peroxy-radical which competes with a bimolecular process; for example, in the case of ethyl alcohol the essential reactions appear to be:

$$\begin{aligned} &RO_2\cdot \rightarrow CH_3CHO + HO_2\cdot \\ &RO_2\cdot + RO_2\cdot \rightarrow 2\,CH_3CO_2H + H_2O_2 \end{aligned}$$

In the early work, anthraquinone sulphonate (Q) was used as the sensitizer, thus

$$\begin{aligned} &Q \xrightarrow{h\nu} Q^* \\ &Q^* + RH \rightarrow QH\cdot + R\cdot \\ &R\cdot + O_2 \rightarrow RO_2\cdot \end{aligned}$$

Recently hydroxyl radicals, produced by the action of ultra-violet light on hydrogen peroxide, have been used as the hydrogen atom abstractors, and it has been shown that their action is much less specific than that of excited anthraquinones. Whereas for anthraquinones the results can be accounted for by assuming abstraction of an α-hydrogen atom, it appears necessary to assume that hydroxyl radicals can abstract hydrogen atoms at other positions.

A subject of great interest to the Association is that of the fine structure in cellulosic materials. Work is still proceeding on ways of determining whether the microfibrillar structures observed could be complete or partial artefacts. During the past year or so, two approaches to the problem of determining the mechanism of formation of structure in solution-spun polymers have been started. The first method is to follow the volume changes during gelation of cellulose acetate in different solvents. The second one is to study the light-scattering of the solution.

A possible complication in interpreting the results of stress-birefringence measurements is that, in general, birefringence can be caused not only by the orientation of anisotropic polymer units but also by anisotropy in the spatial configuration of these units. Experimental departures from the simple orientation theory in solvent-swollen polymer systems have been classified under the general heading of 'Wiener effect'. Some measurements of the photo-elastic properties of swollen cross-linked rubbers have recently been made in this connexion. The effect of solvent is found to be small yet significant, but its dependence on the solvent refractive index is not of the form corresponding to the simple theory put forward by Wiener. A rigorous theoretical treatment of the transmission of light through a two-component birefringent medium has been started. It has been shown that the Lorenz-Lorentz relation is not adequate to relate birefringence to anisotropy of polarizability in stretched polymer systems and that the change in local environment when a single polymer chain is stretched can make a significant contribution to the birefringence. This effect is likely to be most important in dilute solutions where individual chains scarcely interact, but the effect may also make a small contribution to the birefringence of bulk polymers.

Certain equations relating stress and flow history, derived for polymer solutions on the basis of a network model, have been used to calculate the stress components in steady shear flow and, more recently, the deformations which occur when some or all of these components are made zero[2]. Some preliminary measurements of normal stress components in steady shear flow have been made with a newly developed cone-and-plate apparatus; a diaphragm-capacity gauge with a response time of about one second is used to measure the distribution of pressure over the plate.

Two researches on the absorption of water by crystalline polymers have been started. In the first one measurements of the moisture content of a number of textile polymers in fibre and film form have been made over a wide range of humidities and temperatures. In Urquhart's work[3] it was reported that the isotherms crossed over at high relative humidities for cotton. This work, which was started after discussion with Dr. Urquhart, does not confirm this result. An attempt will be made to correlate these measurements with the 'accessibility' of these samples of material as determined by deuterium exchange with deuterium oxide. The second research is concerned with the amount of moisture taken up by cellulose after different amounts of acid hydrolysis. In the case of cotton it has been reported that the amount of moisture absorbed first decreases with time of hydrolysis, goes through a minimum and then increases, finally levelling off and becoming independent of further hydrolysis. This result has been confirmed for cotton but, in the case of viscose, no minimum has yet been found. It may be that there is a minimum for a very small amount of hydrolysis, and this aspect is being investigated. In order to interpret these results it is necessary to make certain assumptions about the crystallite size distribution, so that the work may throw further light on both the fine structure of cellulose and the mechanism of water absorption.

Experimental work to test the fundamental theory of the geometry of yarn structures has been very fruitful. Measurements have been made of the filament path in the yarn, the packing density across the yarn section and the variation in filament twist across the yarn section. Further work on the geometry is continuing and, in the next few months, a study of the relation between the mechanical properties of the yarn and those of the constituent filaments will be started. Initial experiments using rubber as a model, which has the advantage of well-defined elastic behaviour, have already been made.

An agreement has been negotiated with a firm to produce and market most of the electronic instruments developed by the Association. The prototype electronic weft-straightener has functioned to the satisfaction of a member firm and discussions for its production are taking place. A new instrument, based on a pneumatic principle, has been developed for measuring the degree of 'raise' on raised fabrics. This instrument shows considerable promise, not only as a means of assessment, but also as a control instrument for raising machinery. The simple method of measuring warp tension in looms has been improved and instruments are undergoing tests in a number of member firms. The method may also have application in the control of tension in sizing, and suitably modified instruments are about to be evaluated in sizing machinery both at the Association and in the premises of member firms.

As mentioned earlier in this article, the work on machinery development has been restricted by internal reorganization. However, another method of controlling vibration in speed-frames has been developed and is in process of being evaluated. As for fluid beds, a full-scale single-pass bed has been constructed and this is being used for measurements of heat transfer and to assess how far laboratory data on resin-baking and dyeing are applicable under conditions approaching those in a practical machine. Apart from this, most of the development work is concentrated on designing a fluid bed suitable for dyeing fabrics constructed of hydrophobic fibres.

The number of staff is almost the same as last year. The total is 261 made up as follows: research staff, 85; laboratory and technical assistants, 75; engineering, drawing office, and maintenance staff, 60; library and administrative staff, 32; and canteen staff, 9.

L. A. Wiseman

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[1] *Nature*, 179, 1229 (1957).

[2] "Rheology of Elastomers", 79 (Pergamon, 1958). *Rheologica Acta*, No. 2 (in the press).

[3] *J. Text. Inst.*, 15, 559 (1924).

DESIGN AND MANAGEMENT OF A NUCLEAR SCIENCE LABORATORY

By Prof. A. J. WOODALL, O.B.E., C. G. WILSON, Dr. A. L. JONES and D. K. THOMAS
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THE following description of a laboratory specially designed for teaching nuclear physics and chemistry at the Royal Military College of Science, Shrivenham, may be helpful to educational institutions embarking on work in this field. This laboratory has been in full use for approximately two years and it is now possible to make some assessment of the merits of the various special features incorporated in the design.

The laboratory caters for students, who range from young officers reading for science and engineering degrees to more senior officers on specialist courses. They are mostly pressed for time and more concerned with modern applications than with the history of the subject. Accordingly, modern techniques such as electronic counting are employed in experiments on properties of radioactive substances and their radiations rather than the traditional devices such as electroscopes and electrometers. The latter still occupy an honourable position in the honours degree laboratories of the College.

The subject-matter of this course has its potential hazards; this is emphasized by maintenance of a very high standard of laboratory discipline, with proper emphasis on handling precautions and health safety techniques. Maintenance of this standard is greatly assisted by the clean lines of the light airy rooms.

The laboratory was completed, inexpensively and rapidly, by the conversion of an existing 'Romney hut', the main virtue of which was a sound concrete floor, some 75 ft. by 36 ft., protected by a semi-cylindrical water-tight shell of galvanized iron. Insertion of a false ceiling and suitable vertical divisions created rooms of normal shape and voids which provide for certain services and for the ventilation system, as indicated in the typical transverse section of Fig. 1. A substantial central wall divides the building longitudinally into physics and chemistry sections. The physics side contains a nuclear physics laboratory, a gamma-radiography room, a small counting room, a photographic dark room, a small workshop and an office. The subdivision on the chemistry side, based on ascending levels of radioactivity, provides a preparation room, a monitoring room and three radiochemical laboratories in which the anticipated level of activity is graded from negligible to dangerous. This arrangement leads to a gradation of working levels with the potentially quite dangerous activation room on the chemistry side opposite the radiography room, so that both are remote from the shielded counting room and the regions in which prolonged work is performed. The radioactive sources, in suitable individual containers, are kept in massive concrete and iron safes, one in each of the two main divisions.

The rooms are separately ventilated into the roof void above the light-alloy false ceiling, which is stiffened by overhead girders and rests on the partition walls. This system minimizes inter-

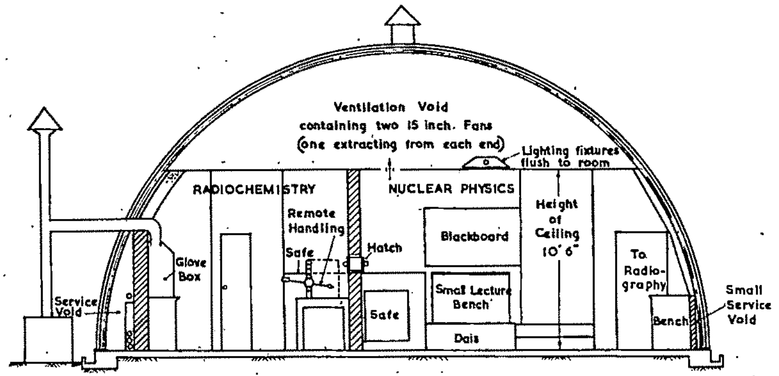

Fig. 1

change of active material between the rooms. The flow of air is governed by a pair of powerful fans and it is expelled through the original ventilating shafts on top of the building. The intake is through individual gratings to prevent one room drawing air from another. The chemistry laboratories have an additional air flow when the fume-hoods are in operation. This system could have air-filters added on the outflows if necessary. It should, however, be mentioned that current opinion inclines to make the air-flow downwards because this is assisted by the normal movement of those grosser particles which become airborne.

All exposed wall surfaces are smooth and coated with hard glossy paint, light in colour, so that splashes are easily visible. The concrete floor is completely covered with waxed polished linoleum and the joins sealed. The lighting is concealed, and all services are, whenever possible, out of sight and carried between laboratories above the false roof and inside the vertical walls. In this way surface decontamination is greatly facilitated. The main dividing wall is provided with two lead-lined hatches, so that radioactive sources can be passed from the chemistry laboratory to the physics laboratory without passing through the monitoring room.

All effluent from the monitoring room and the radiochemical laboratories passes into external delay tanks, arranged below ground-level. Such effluent is not finally discharged until the level of activity has been checked as being below the maximum agreed with the relevant authority. It should be noted that public health authorities must be consulted about all arrangements of this kind. Solid waste which might be active is put into paper bags in foot-operated medical-type waste bins. These are later sealed, and if passed for disposal, are burnt in an incinerator, remote from any habitation.

There are two neutron sources in the activation room. The larger source, an antimony–beryllium mixture with a nominal gamma-ray activity of 1 curie, is housed in a drum of paraffin wax, surrounded by a concrete cylinder built from interlocking rings with aligned holes which form vertical channels for inserting specimens for irradiation. In this way, tracer quantities of artificially radioactive materials are regularly prepared. The smaller source is of a radium–beryllium mixture, having associated gamma-activity equivalent to 20 mgm. of radium. Normally housed in a converted dustbin containing a hollow lead cylinder embedded in paraffin wax, this source is used for physical experiments involving neutrons.

Except in emergency, the monitoring room is the only means of entry to the radiochemical laboratories. Here, all staff and students check themselves for contamination before entering and when leaving the laboratories. The hand-basins have foot-operated taps, and powerful hot-air hand-dryers are used in place of towels, to reduce cross-contamination risks. All personnel wear protective overalls in all the laboratories, but, in addition, rubber gloves and canvas overshoes are worn in the radiochemical laboratories. The intake of radioactive material is so serious a hazard that eating, smoking and the like are strictly forbidden except in the office, which is adjacent to the main entrance. Since familiarity often causes research workers as well as technicians and industrial workers to become lax, and the consequences of mistakes may not show for long periods, it is essential to be rigid in enforcing this discipline, but the reasons for all rules should be fully understood and no avoidable hardship should be inflicted. For example, the hand-dryers must be very efficient so that there is no temptation to hasten operations with a surreptitious use of a handkerchief. Staff and students carry film badges and sometimes also quartz-fibre dosimeters, and a diary is maintained of individual radiation doses so recorded.

The laboratory furniture is normal, but bench tops are protected by stout water-proof waxed paper which can easily be removed after contamination. Chemical experiments are 'contained' in stainless steel trays lined with tissue paper. Normal chemical manipulation is drastically modified, there being no sniffing and tasting, while wash-bottles are replaced by plastic squeeze-bottles and pipettes are piston-operated. The preparation of sources which are powerful alpha- or beta-emitters is carried out in a glove-box, having rubber gloves sealed into apertures in the 'Perspex' windows: strong gamma-emitters are handled behind an appropriate shielding wall of interlocking lead bricks by remote handling gear. The weight of the walls is taken by the reinforced concrete bench which, incidentally, shields the lower part of the body.

Most of the apparatus on the physics side comprises various forms of radiation detector and counting equipment. The standard counting unit consists of a Geiger–Müller tube housed in a lead 'castle' and connected to a dekatron scaler by a small pre-amplifier and delay circuit. The voltage supply for the Geiger tubes is provided by power packs, each capable of feeding several units. In addition, three rate-meters are available for the direct measurement of counting rates, using end-window or liquid detectors. A pen recorder in conjunction with a rate-meter enables the decay curve of some isotopes to be traced directly. Battery-operated radiation monitors and Radiac equipment are used in simple experiments, apart from serving as laboratory monitors and survey meters. More specialized equipment includes two scintillation counters (one is incorporated in a single-channel gamma-ray spectrometer); two vibrating-reed electrometers, used for alpha-ray range determination and for ionization current measurements, etc.; and a home-made, thin-lens type, beta-ray spectrometer.

Weak radioactive sources (micro-curies) are prepared by evaporation from nickel planchettes of diluted radioactive solutions obtained from the Radiochemical Centre, Amersham. Infra-red lamps are used for this operation to avoid possible spray. The planchettes are mounted on thin 'Perspex' sheets designed to fit into a lead castle. More active sources (milli-curies) as wire or foil are obtained from Harwell. For gamma-radiography, the main source is of iridium-192 of several curies strength, used in a gamma-ray 'bomb' container. When the stronger sources are used in the exposed state in an experiment, lead brick shielding is used to ensure a reasonably low background throughout the laboratory. It has been found possible to cast suitable lead bricks very cheaply in the college workshops.

The experiments carried out in the physics section include the characteristics of the absorption of alpha-, beta- and gamma-rays; the calibration of dosimeters and of film badges; the survey of contaminated ground; the determination of beta- and gamma-ray spectra; the slow neutron flux obtained from a neutron source immersed in water; the characteristics of Geiger and scintillation counters; the decay curves of irradiated silver; the use of nuclear emulsions; and the production of gamma-radiographs. On the chemistry side, the experiments include the production and isolation of radioactive iodine; slow-neutron activation analyses; isotopic dilution analyses; separation using exchange resins and the solubility of lead sulphate. The experiment schedules are modified to cater for the differing academic levels of students using the laboratory.

The laboratory caters for a maximum of thirty students at a time, of whom about twenty would be on the physical side and the rest doing chemical experiments. This represents a fairly high concentration of personnel in the working space, and constant vigilance is required to prevent excess local background, especially when sources are moved. Writing records of experiments is then usually carried out in a neighbouring building.

The capital cost of conversion, including benching, ventilation and drainage, for a laboratory on this scale, is likely to be in the region of £5,000; a brand-new building would cost much more and take longer to construct. Equipment at the standard adopted for this laboratory is comparable in cost. It is felt that the high initial cost of carefully chosen commercial apparatus has been fully justified in the sequel by the excellent service it has given and by the low maintenance costs.

We wish to record our indebtedness to those members of the Atomic Energy Research Establishment and the Atomic Weapons Research Establishment, who were consulted during the planning stage, for their valuable advice and to the Garrison Engineer at Shrivenham and his staff for their co-operation and professional skill. To those who contemplate similar ventures we would warmly recommend a close study of laboratories of high standard. There are many points of detail which cannot be included in an account of this kind, but which make a difference to smooth and efficient running of the laboratories and reduce the risk of accident. The close co-operation of physicist and chemist in the design and operation of the laboratory has played a notable part in promoting its efficiency and its usefulness to the students, who gain a more balanced picture of the subject in this way.

THE ELECTRICAL RESEARCH ASSOCIATION

THE Electrical Research Association has recently completed its first year of work, under the direction of Dr. H. G. Taylor, at the new laboratories at Leatherhead. Changes and developments are reflected in some measure in the form as well as in the content of the annual report for 1957* which was presented at the annual general meeting held on May 7.

It is with regret that we record the death, on the day of the meeting, of Mr. F. H. Bramwell, chairman of the Council of the Association, over whose signature the report of the Council appears in the annual report.

In the matter of framing research policy it is noteworthy that the Council now has the benefit of drawing upon the knowledge and experience of an Advisory Research Board, the constitution of which is given in the report under the list of committees and panels. On the administrative side a new post of research manager has been established and is occupied by Mr. L. Gosland, who was formerly head of the switchgear department.

In order to form some assessment of the extent to which the Association's research effort is co-ordinated with the interests of members, a questionnaire was issued during the year inviting opinion as to the application of the Association's research funds. The results were weighted in relation to the value of members' subscriptions and a final percentage analysis prepared. This analysis is found to be in reasonably good correlation with the relative scale of the Association's activity in its various fields, and although it does not show a pressing demand for work in any field in which the Association is not at present engaged, there is a significant emphasis on the subject of the nuclear irradiation of dielectrics, cathodic protection, climate proofing, nuclear power and semi-conductors. The results of this questionnaire provide very useful guidance for future policy.

Mention is made of the difficulties which have been experienced in filling vacancies on the senior scientific staff and of the efforts which are being made to interest young university graduates in engineering and in physics in the work of the Association. The total number of staff employed by the Association at the end of the year under review was 348.

In the field of insulation, which constitutes one of the major areas of the Association's work, a result of considerable practical significance has been obtained in the demonstration of the importance of moisture content in controlling the discharge inception-level of cellulose. Confirmation has also been obtained, in the case of one of the new high-density polyethylenes, of the recently propounded electro-mechanical theory of breakdown.

It is interesting to note that it has been found desirable to initiate a fundamental study of the mechanism of oxidation of hydrocarbon oils. This programme is being carried out in three university departments. The need to supplement the great body of existing knowledge of the behaviour of hydrocarbon oils as insulants for electrical apparatus arises from the urge to raise the working temperature of transformers.

In another important branch of the Association's work, that of circuit breakers and circuit-breaking phenomena, progress is reported in the breaking of both low and high currents in vacuum and, in relation to the arc itself, theoretical predictions of high arc-core temperatures (35,000° K.) have been confirmed by spectroscopic measurements.

Two interesting full-scale experiments relating to electric power systems are reported. These were carried out in collaboration with the Central Electricity Authority. The stability of a large national electricity supply system under conditions of overload or of transient disturbance is naturally a matter of importance and studies of system stability are made using network models known as network analysers. The validity of the results of such studies is in large measure dependent upon the correctness of the values of the system constants used in setting up the model system, and these have often to be based on indirect computation. There is therefore great interest in the carrying out of stability tests on actual power systems whenever such full-scale tests can be arranged. The first large-scale experiments on system stability to be made in Britain were carried out during a Bank Holiday week-end at the Cliff Quay Generating Station of the Central Electricity Authority. The performance of the system was predicted on three models, the network analysers of the Association and of the Associated Electrical Industries organization together with the 'Micro Réseau' of Electricité de France. The results of these tests will be communicated in a group of papers to be read before the Institution of Electrical Engineers. It is, however, stated in the report that the behaviour of the system was in general agreement with prediction.

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* Electrical Research Association. Thirty-seventh Annual Report for the year ended 31st December, 1957. Pp. 119+8 plates. (Leatherhead: Electrical Research Association, 1958.)

The second experiment concerned the strength of the foundations of transmission towers. The opportunity to make tests on a series of erected towers occurred as a result of the decision of the South Eastern Electricity Board to discontinue the use of a section of 33 kV. line in the Guildford area. Mechanical loading tests were carried out on the towers with the view of determining the strength of their foundations. The report on these tests has not yet been issued, but it is stated that the strength of the foundations was considerably less than had been expected.

The Association's work on intrinsically safe circuits for measurement and control in an atmosphere of explosive gases has included acetylene and ethylene. As a result of this, ethylene has been included in the list of gases covered by the appropriate British Safety Standard, and certification is now available for apparatus to be used in an ethylene atmosphere.

An attractive new feature of the annual report is the inclusion of a group of photographs illustrating aspects of the research work. One of these is a reproduction of a thunderstorm distribution map for 1957 for England, Wales and Scotland. The accumulation by the Association of data concerning lightning flashes is proving to be of increasing value. Towards the end of the report is given a list of universities, colleges, Government establishments and national authorities in which the extramural research of the Association is being carried on, in each case stating the subject of the research programme and names of those responsible for the work.

J. GREIG

GENETICS OF BETA-GLOBULIN POLYMORPHISM IN BRITISH CATTLE

By G. C. ASHTON

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IN a preliminary communication five serum β-globulin phenotypes of cattle, identified by starch gel electrophoresis, were described[1]. A sixth phenotype has now been found, and as a result it is possible to propose a genetic mechanism for the system.

The six phenotypes are shown in Fig. 1 together with the postulated genotypes. The mating data and symmetrical appearance of the phenotypes suggested that a three-allele system (genes β^A, β^D, and β^E) with no dominance is operative. The homozygotes type I (β^A/β^A), type IV (β^D/β^D), and type VI (β^E/β^E) are individually recognizable. The heterozygotes are also recognizable as such; thus type II (β^A/β^D) is clearly a composite of types I and IV, type III (β^D/β^E) a composite of types IV and VI, and type V (β^A/β^E) a composite of types I and IV. Equal mixtures of the appropriate homozygous β-globulin sera are indistinguishable qualitatively from genuine samples of heterozygous serum when run side by side. Each of the phenotypes I–VI is thus a single genotype, and it is therefore appropriate to discard the numerical terminology and name each phenotype by its genotype. The expected distribution of phenotypes (genotypes) is shown in Table 1, while pooled mating data for a number of breeds are shown in Table 2. The expected and observed results agree when tested by the χ^2 test.

In the preliminary communication[1] only five phenotypes had been recognized, and to fit the mating data reported at that time it was necessary to postulate a series of linked genes. However, with the finding of the sixth phenotype (β^{EE}) the genetic mechanism became clear and it was apparent that five of the 150 matings previously reported[1] (two I × IV → I; one I × IV → IV; one III × V → I; one III × V → IV) were not possible on the 3-allele

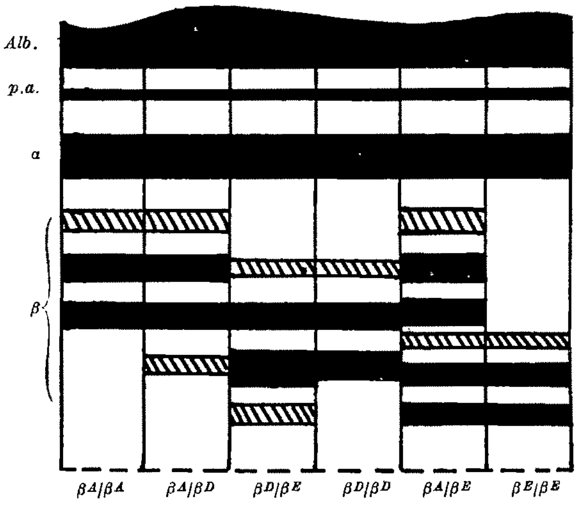

Fig. 1. The six β-globulin types. *Alb.*, albumin; *p.a.*, post albumin; *a*, *a*-complex; *β*, *β*-globulins. Solid bands, intense staining; cross-hatched, less intense

Table 1. EXPECTED MATING RESULTS AND DISTRIBUTION OF OFFSPRING ON THREE-ALLELE THEORY

Parents	Distribution of offspring					
	β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
$\beta^{AA} \times \beta^{AA}$	1·0	—	—	—	—	—
,, β^{AD}	0·5	0·5	—	—	—	—
,, β^{DE}	—	0·5	—	—	0·5	—
,, β^{DD}	—	1·0	—	—	—	—
,, β^{AE}	0·5	—	—	—	0·5	—
,, β^{EE}	—	—	—	—	1·0	—
$\beta^{AD} \times \beta^{AD}$	0·25	0·5	—	0·25	—	—
,, β^{DE}	—	0·25	0·25	0·25	0·25	—
,, β^{DD}	—	0·5	—	0·5	—	—
,, β^{AE}	0·25	0·25	0·25	—	0·25	—
,, β^{EE}	—	—	0·5	—	0·5	—
$\beta^{DE} \times \beta^{DE}$	—	—	0·5	0·25	—	0·25
,, β^{DD}	—	—	0·5	0·5	—	—
,, β^{AE}	—	0·25	0·25	—	0·25	0·25
,, β^{EE}	—	—	0·5	—	—	0·5
$\beta^{DD} \times \beta^{DD}$	—	—	—	1·0	—	—
,, β^{AE}	—	0·5	0·5	—	—	—
,, β^{EE}	—	—	1·0	—	—	—
$\beta^{AE} \times \beta^{AE}$	0·25	—	—	—	0·5	0·25
,, β^{EE}	—	—	—	—	0·5	0·5
$\beta^{EE} \times \beta^{EE}$	—	—	—	—	—	1·0

Table 2.

Parents	Distribution of 325 single offspring					
	β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
$\beta^{AA} \times \beta^{AA}$	13	—	—	—	—	—
,, β^{AD}	23	30	—	—	—	—
,, β^{DE}	—	3	—	—	4	—
,, β^{DD}	—	42	—	—	—	—
,, β^{AE}	5	—	—	—	3	—
,, β^{EE}	—	—	—	—	2	—
$\beta^{AD} \times \beta^{AD}$	10	14	—	8	—	—
,, β^{DE}	—	1	2	1	3	—
,, β^{DD}	—	32	—	39	—	—
,, β^{AE}	3	3	4	—	1	—
$\beta^{DE} \times \beta^{DE}$	—	—	7	3	—	2
,, β^{DD}	—	—	6	12	—	—
,, β^{AE}	—	1	3	—	1	3
$\beta^{DD} \times \beta^{DD}$	—	—	—	27	—	—
,, β^{AE}	—	4	2	—	—	—
,, β^{EE}	—	—	4	—	—	—
$\beta^{AE} \times \beta^{AE}$	1	—	—	—	2	1

No matings between β^{EE} and β^{AD}, β^{DE}, β^{AE} or β^{EE} have been observed

theory indicated by the sixth phenotype. These mating results were re-investigated and in each case proved to be false after critical examination. In this connexion Rendel[2] found that the stated parentage was in error in about 8 per cent of sire-dam-offspring families blood-grouped in Sweden. It is thus probable that the β-globulin system will be of assistance in checking parentage.

The five phenotypes previously reported[1] were found independently by Smithies and Hickman[3]; on the basis of 71 mating results within two herds they postulated a three-gene theory for cattle β-globulins also, although their interpretation of the expression of each gene has proved to be incorrect.

In order to establish reliable gene frequency data for each breed of cattle it is necessary to examine a representative cross-section of each breed. It is difficult to get a truly random sample by examining cattle indiscriminantly, due to the preponderance of herds using one or two bulls only. However, with the advent of artificial insemination representative groups of pedigree bulls drawn from many sources have been established, and these bulls each serve many hundreds of cows and heifers every year.

Table 3 shows the distribution of phenotypes in bulls standing at Milk Marketing Board cattle-breeding centres compared with bulls standing at other centres.

Gene frequencies for each breed from both groups of centres are shown in Table 4. The results were calculated from the relationships, $A = (2\beta^{AA} + \beta^{AD} + \beta^{AE})/2N$, $D = (\beta^{AD} + \beta^{DE} + 2\beta^{DD})/2N$, and $E = (\beta^{DE} + \beta^{AE} + 2\beta^{EE})/2N$, where β^{AA}, β^{AD}, etc. are the numbers of animals of this phenotype found for any given breed and N is the total number of animals, and where A, D and E are the frequencies of genes β^{A}, β^{D} and β^{E} respectively. The standard errors of the gene frequency estimates were calculated from the expression $\sqrt{1/2N.\ [g(1-g)]}$, where g is gene frequency.

It will be seen that the gene frequencies calculated from both groups of breeding centres are consistent for each breed, within the standard errors found. The gene frequencies found for each breed, therefore, are probably fairly representative for that breed in Britain.

It is evident that the frequency of β^{E} is greater in those breeds originating in the climatically more severe parts of the British Isles. Thus β^{E} is absent in Jersey, Guernsey, Devon and South Devon cattle, confined mainly to the south and south-west of England, while it is most frequent in cattle of Scottish origin. Furthermore, the frequency of this gene within the Ayrshire breed is associated with the location of the herd. In a herd using artificial insemination selected at random in Essex the frequency of β^{E} was 0·118 ± 0·025 (80 animals), which is in agreement with the expected value (cf. Table 3). In a comparable herd (67 animals) in Aberdeenshire, on the other hand, the frequency of β^{E} was 0·261 ± 0·037, while Hickman and Smithies[3] found a frequency of 0·279 ± 0·049 in an Ontario Ayrshire herd (42 animals). These results suggest that β-globulin polymorphism in cattle may be concerned with climate

Table 3. DISTRIBUTION OF PHENOTYPES OF 808 PEDIGREE BULLS AT CATTLE-BREEDING CENTRES

Breed	Origin*	Distribution of phenotypes					
		β^{AA}	β^{AD}	β^{DE}	β^{DD}	β^{AE}	β^{EE}
Friesian	*M*	58	85	8	54	9	0
	O	9	16	1	14	7	0
Shorthorn	*M*	42	42	1	18	5	0
	O	16	11	0	6	0	0
Hereford	*M*	16	21	1	27	1	0
	O	3	2	0	6	0	0
Ayrshire	*M*	6	26	14	32	3	0
	O	3	16	3	18	3	0
Aberdeen Angus	*M*	18	7	0	4	9	0
	O	5	4	1	2	2	0
Guernsey	*M*	10	19	—	8	—	—
	O	6	11	—	8	—	—
Jersey	*M*	17	15	—	4	—	—
	O	7	5	—	1	—	—
Devon	*M* and *O*	5	7	—	12	—	—
South Devon	*M* and *O*	1	4	—	9	—	—
Galloway	*M*	0	1	0	0	1	2

* *M*, Milk Marketing Board cattle-breeding centres (22); *O*, other cattle-breeding centres (9).

Table 4. FREQUENCIES OF GENES β^{A}, β^{D} AND β^{E} AND THEIR STANDARD ERRORS

Breed	Origin*	Gene frequencies			Standard errors ±		
		β^{A}	β^{D}	β^{E}	β^{A}	β^{D}	β^{E}
Friesian	*M*	0·490	0·470	0·040	0·024	0·024	0·062
	O	0·436	0·479	0·085	0·051	0·052	0·029
Shorthorn	*M*	0·606	0·366	0·028	0·032	0·033	0·011
	O	0·651	0·349	0·000	0·053	0·053	—
Hereford	*M*	0·409	0·576	0·015	0·043	0·043	0·011
	O	0·364	0·636	0·000	0·102	0·102	—
Ayrshire	*M*	0·253	0·642	0·105	0·041	0·038	0·024
	O	0·291	0·639	0·070	0·049	0·052	0·028
Aberdeen Angus	*M*	0·684	0·198	0·118	0·075	0·065	0·017
	O	0·572	0·321	0·107	0·106	0·100	0·066
Guernsey	*M*	0·527	0·473	—	0·058	0·058	—
	O	0·460	0·540	—	0·071	0·071	—
Jersey	*M*	0·681	0·319	—	0·055	0·055	—
	O	0·792	0·208	—	0·083	0·083	—

* *M* and *O* as in Table 3.

tolerance. It is significant that the average heat adaptability coefficients of some breeds of cattle, quoted by Findlay[4], are in inverse order to the β^E frequencies; for example, Jersey adaptability coefficient 79, β^E nil; Hereford 73, β^E 0·013; Aberdeen Angus 59, β^E 0·115. In view of the high adaptability coefficient (89) of Brahman cattle, it will be worth while investigating the β-globulins of these animals.

It is noteworthy that recently described β-globulin polymorphism in humans sharply distinguishes the black and white races[5]. Polymorphism involving the β-globulins has also been found in sheep[6], goats, horses and rhesus monkeys[7]. This may prove to be one mechanism, therefore, by which a species is able to adapt itself to both temperate and tropical climates.

I gratefully acknowledge the co-operation of the veterinary officers and managers of the various artificial insemination centres in sending samples of bull blood, and of Mr. W. Thomson, of the Duthie Experimental Stock Farm, Aberdeenshire, for supplying blood samples from Ayrshire cattle. I am indebted to Mr. J. C. Gower of Rothamsted for help with the calculation of gene frequencies and errors.

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GROUP-TRANSLOCATION: A CONSEQUENCE OF ENZYME-CATALYSED GROUP-TRANSFER

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RECENT research on bacterial permeability[1], metabolism[1,2] and adaptation[2] has shown that the kinetics of the passage of metabolites through the plasma-membrane of bacteria closely resembles enzyme kinetics; and it has been inferred that certain protein components of the plasma-membrane may act as highly specific conductors of membrane-transport. We have suggested that normal enzyme systems are the conductors of membrane-transport and that metabolic energy is generally converted to osmotic work by the formation and opening of covalent links between enzymes or co-enzymes in the membrane and the transported 'molecules' that are carried as chemical groups exactly as in enzyme-catalysed group-transfer reactions[1,3]. This view has been supported by the observation that the plasma-membrane of certain bacteria is partly constituted of normal enzymes and carriers[4]. On the other hand, using a less direct but very elegant approach to the problem, Cohen and Monod have recently adopted a view that they attribute to Danielli[5]. They suppose that "the rapid permeation of hydrophilic organic compounds into cells is ensured by stereospecific and functionally specialized protein components of the plasma-membrane". They have introduced the word 'permease' to distinguish these supposedly functionally specialized catalysts of facilitated diffusion and also of active transport from metabolic enzymes, and have thus retained the old problem of the mechanism of energy coupling between metabolism and the catalysts of the osmotic processes.

The object of the present communication is to amplify our own conception of the connexion between normal enzyme catalysis and the movement of chemical groups in space[3], and to demonstrate again in a more general context that the active transport of metabolites can be adequately explained in orthodox biochemical terms.

The recent developments on the border between enzyme kinetics and metabolic enzymology have led to a spatially more realistic description of enzyme catalysis than was generally accepted before, by focusing attention upon the enzymic transfer of chemical groups and by considering the enzyme as a reactant in group-transfer reactions[1,7]. For example[7], certain phosphokinases (E) are believed to mediate in the transfer of phosphoryl between adenosine triphosphate (ATP) and the substrate (S) being phosphorylated (forming EP) as follows:

$$\mathrm{ATP} + \mathrm{E} \rightleftharpoons \mathrm{ADP} + \mathrm{EP}$$
$$\mathrm{EP} + \mathrm{S} \rightleftharpoons \mathrm{E} + \mathrm{SP}$$

Evidently there must be a spatial movement (translocation) of phosphoryl relative to adenosine diphosphate and the substrate in relation to the enzyme molecule as represented in Fig. 1, supposing the reaction to be on the enzyme 'surface', or as in Fig. 2 supposing the reaction to occur in a cleft in the molecule—the movement of phosphoryl from adenosine diphosphate to the substrate possibly involving thermal distortion of the enzyme itself as suggested previously[3]. The group-translocation accompanying group-transfer illustrated by this example is, we suggest, a phenomenon general to many enzyme-catalysed group-transfer reactions, including hydrogen and electron transfer. The translocation implicit in the transfer process would, of course, have no macroscopic effect in a homogeneous system and might, under these conditions, be passed over as unimportant. If the system is not

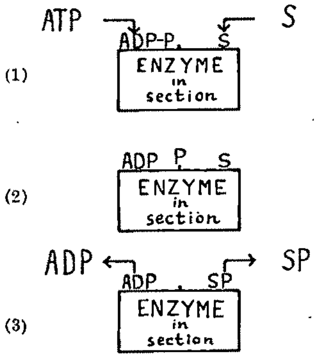

Fig. 1

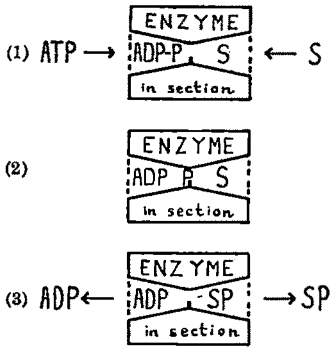

Fig. 2

homogeneous, however, group-translocation may have a biochemically important macroscopic consequence.

It is possible to envisage both a macroscopic and a microscopic type of inhomogeneity that may cause group-translocation to show macroscopically. In the macroscopic type, the enzyme molecules must be orientated in a membrane in such a way that certain components react with the active centre from one side (or from both sides) while one or more other components react only from the other side. The essential consequence of this state of affairs would be that a chemical group must pass across the membrane during the enzyme-catalysed reaction. The enzyme as depicted in Fig. 2 could give rise to the effect that we are describing simply by being imbedded in an inert osmotic barrier with the cleft connecting the phases on either side; and even the more usual representation (Fig. 1) would give rise to the same effect if the enzyme molecules were orientated so that the part of the osmotic barrier lying close to the active centre formed a cleft connecting the phases on either side like that envisaged in the enzyme itself in Fig. 2. In this way, membrane-transport and metabolism can be integral consequences of the same enzyme-catalysed process.

The microscopic type of inhomogeneity that may cause group-translocation to be macroscopically significant requires the participation of a second enzyme that can catalyse a change in the product of the first enzyme reaction. In this case we can visualize the inhomogeneity as a pairing of the different enzyme molecules so that a product of the first enzyme reaction diffuses to the active centre of the second enzyme faster than it escapes into the neighbouring region of the medium. The possible consequences of this type of inhomogeneity are of more than theoretical interest, because the grouping of enzymes and carriers into double- or many-functional particles within which the reactions are closely integrated is well known[8].

The highly organized particle and membrane systems of most animal and plant cells recently discovered have presented new problems of spatial metabolic organization that have taxed the imagination of biochemists[8]. We suggest that the concept of group-translocation may provide the basis for a new but essentially orthodox biochemical approach to these problems. A more detailed account of group-translocation will be published in due course[9].

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OXIDATIVE METABOLISM OF POLYCYCLIC HYDROCARBONS BY SOIL PSEUDOMONADS

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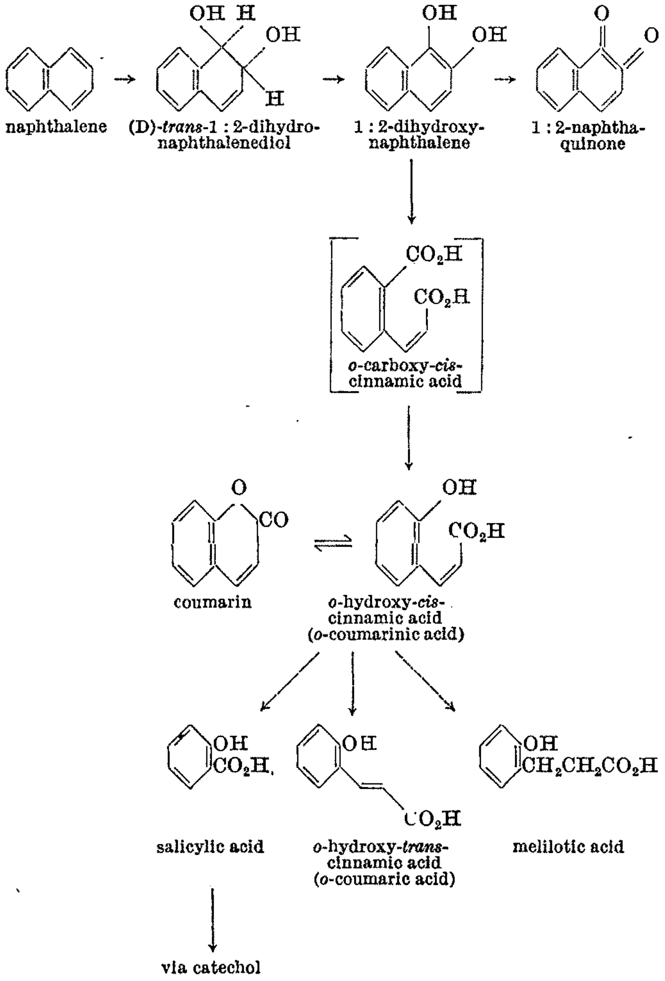
THE intermediary pathways through which monocyclic aromatic compounds are metabolized by soil bacteria have been summarized by Evans, Smith, Linstead and Elvidge[1]. It has been known since the work of Tausson[2] that several polycyclic hydrocarbons, for example naphthalene, anthracene and phenanthrene, also serve as substrates for certain soil organisms and are metabolized completely. A knowledge of the precise method of biochemical attack on these polynuclear hydrocarbons may help towards understanding the microbial oxidation of naturally occurring condensed ring systems.

In naphthalene cultures of a *Pseudomonad* strain, Strawinski and Stone[3] identified salicylic acid; Walker and Wiltshire[4], in addition, isolated D-*trans*-1 : 2-dihydro-1 : 2-dihydroxynaphthalene, and showed by the sequential induction technique that both were intermediates in the metabolism of this hydrocarbon. The latter workers also studied the breakdown of 1-chloronaphthalene[5] by a suitable organism, identifying 8-chloro-1 : 2-dihydro-1 : 2-dihydroxynaphthalene and 3-chlorosalicylic acid as intermediates. These results made it very probable that C-5 in 1-chloronaphthalene became the carboxyl-C of 3-chlorosalicylic acid. Murphy and Stone[6] found that 1 : 2-naphthaquinone accumulated, eventually in toxic amounts, in naphthalene cultures of their strain of *Pseudomonas*.

Recently, Rogoff and Wender[7,8] have shown that phenanthrene and anthracene are also metabolized through end-ring attack, by members of the genus *Pseudomonas*. Thus, from phenanthrene cultures

Scheme 1. SUGGESTED PATHWAY FOR THE END-RING ATTACK ON NAPHTHALENE BY SOIL *Pseudomonads*


naphthalene
(D)-*trans*-1 : 2-dihydronaphthalenediol
1 : 2-dihydroxynaphthalene
1 : 2-naphthaquinone
o-carboxy-*cis*-cinnamic acid
coumarin
o-hydroxy-*cis*-cinnamic acid (*o*-coumarinic acid)
salicylic acid
o-hydroxy-*trans*-cinnamic acid (*o*-coumaric acid)
melilotic acid
via catechol

they isolated 1-hydroxy-2-naphthoic acid, while anthracene cultures afforded 3-hydroxy-2-naphthoic acid, as intermediates. Both these acids were afterwards metabolized through salicylic acid into the catechol pathway, as shown by sequential induction experiments.

The ultimate product of end-ring fission in the microbial metabolism of polycyclic hydrocarbons is therefore salicylic acid or an analogue. Intermediate stages in the breakdown of the end-ring have not, however, been ascertained.

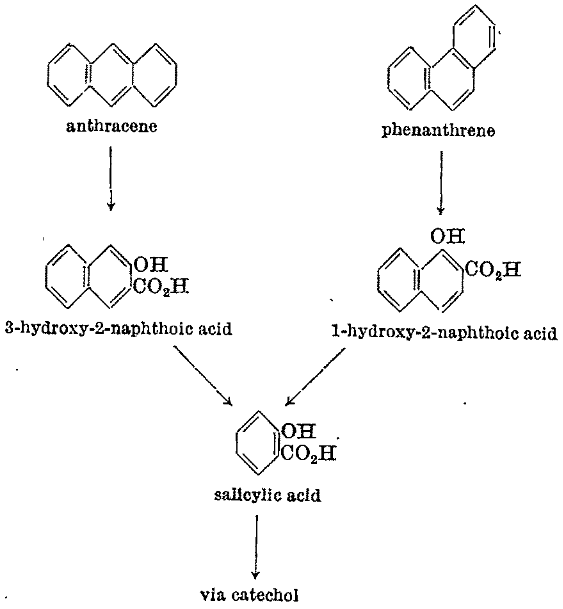
Cultures of a *Pseudomonad* strain isolated from conifer litter, growing ærobically in a simple mineral salts medium[9] with naphthalene as sole substrate, gave coumarin from the acid-ether fraction, detected by smell, and identified by chromatography, absorption spectrum ($\lambda_{max.}$, 277 mμ in water), and mixed melting-point with an authentic sample. It would appear that *o*-hydroxy-*cis*-cinnamate is the actual metabolite present in culture and not coumarin itself, since this would have occurred in the neutral-ether fraction, which was not the case. These cultures also contained, at various times, detectable amounts of *o*-hydroxy-*trans*-cinnamic acid (*o*-coumaric acid), *o*-hydroxyphenylpropionic acid (melilotic acid), and salicylic acid, as shown by their chromatographic separation, fluorescence, absorption spectra, and various colour reactions. Some minor chromatographic spots remain unidentified.

Bacterial cells grown on naphthalene were sequentially induced to oxidize *trans*-1 : 2-dihydro-1 : 2-dihydroxynaphthalene and salicylic acid in accordance with the results of previous workers[4,5], and also to 1 : 2-dihydroxynaphthalene. Coumarin, *o*-coumaric and melilotic acids regularly gave oxygen-uptakes considerably in excess of the control cells, but the rates were rather slower than those of the former substrates. Negative results were obtained with two synthetic *o*-carboxycinnamic acids (m.p. 175° C. and 197–205° C. respectively[10,11]), *o*-carboxyphenylpropionic acid, phthalide acetic acid, *o*-carboxybenzoylacetic acid, and phthalic acid.

A crude cell-free extract prepared from naphthalene-grown cells rapidly oxidized pure 1 : 2-dihydroxynaphthalene, with the consumption of approximately 3 atoms of oxygen, and the liberation of 1 mole of carbon dioxide per mole of substrate. Coumarin was isolated as the major product of this enzyme action, on acidification and ether extraction. By analogy with previous work in this field[1], the immediate product of ring fission is presumably *o*-carboxy-*cis*-cinnamate, but we have no evidence, as yet, of its formation. Neither of the synthetic *o*-carboxycinnamates is acted upon by this crude enzyme preparation, but this may be because they are both varieties of the *trans*-isomer, whereas the bacterial enzyme would be expected to be stereo-specific towards the *cis*-form[12]. The production of *o*-hydroxy-*cis*-cinnamate (isolated as coumarin) is explained by an oxidative decarboxylation of the presumed labile *o*-carboxy-*cis*-cinnamate; the molar gaseous exchange is in agreement with this view.

On the basis of these results, the oxidative

Scheme 2. SUGGESTED PATHWAY FOR THE DISSIMILATION OF ANTHRACENE AND PHENANTHRENE BY SOIL *Pseudomonads* (ref. 8)



microbial metabolism of the end-ring of naphthalene is suggested as proceeding according to the pathway shown in Scheme 1. Naphthalene is first oxidized to the D-*trans*-dihydronaphthalenediol, which is normally dehydrogenated to 1 : 2-dihydroxynaphthalene prior to ring fission, but in certain circumstances (depending on the organism and cultural conditions) further oxidation to the toxic 1 : 2-naphthaquinone occurs. Ring cleavage of 1 : 2-dihydroxynaphthalene is assumed to proceed through *o*-carboxy-*cis*-cinnamate, which is oxidatively decarboxylated to *o*-hydroxy-*cis*-cinnamate. The other related products identified in naphthalene cultures could arise by well-known biochemical reactions from this key intermediate, for example : (*a*) by β-oxidation salicylic acid, afterwards to be metabolized via catechol[13], (*b*) isomerization and reduction, *o*-coumaric and melilotic acids, afterwards to be metabolized by an unknown route.

Our present information as to the pathway of oxidative microbial metabolism of anthracene and phenanthrene is shown in Scheme 2 after Rogoff and Wender[8]. End-ring attack may occur in an analogous manner to that of naphthalene, through the cleavage of 1 : 2-dihydroxyanthracene, and 3 : 4-dihydroxyphenanthrene respectively.

It will be a future task to elucidate the enzymology of this metabolic sequence, and to explore its relevance to the breakdown of polycyclic compounds in general.

H. N. Fernley thanks the Agricultural Research Council for its support.

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ETCHING OF RADIATION DAMAGE IN LITHIUM FLUORIDE

By Dr. D. A. YOUNG
Chemistry Division, Atomic Energy Research Establishment, Harwell

FROM experiments on the coloration induced in potassium chloride by fission fragments allowed to recoil into the crystal, it was proposed[1] that the unannealed recoil tracks consist of individual and aggregated lattice defects with trapped positive holes and electrons. During optical bleaching of the *F*-band, the *F*- and electron-excess centres aggregate to form *R'*-centres along the core of the damage produced by the recoiling fragment, and it was suggested that in respect of chemical properties, that is, precipitation, the recoil track is similar to a heavily jogged dislocation.

The damage produced in ionic crystals by recoiling fission fragments from an external source has now been examined by another technique. It was argued that the thermodynamic potential of the crystal should be increased around those regions of the surface at which the fission fragments are injected, and that this should manifest itself in an enhanced rate of dissolution with respect to the undamaged crystal surface. That is to say, etch-pits should be formed as at dislocations. Accordingly, single crystals of lithium fluoride were cleaved along the {100} plane and fission fragments from a U_3O_8-film 1 mm. distant allowed to enter a portion of the crystal surface at room temperature. The crystals were then etched in the mixture of concentrated hydrofluoric acid (1 part) and glacial acetic acid (1 part) saturated with ferric fluoride, which was recommended for the purpose by Gilman and Johnstone[2]. After etching without agitation for between 1 and 42 min. at 12° C., the crystals were washed in absolute alcohol and dry ether, dried in a warm air current and photographed under oblique illumination in a Vickers projection microscope.

The crystal illustrated in Figs. 1–4 was exposed to a total thermal neutron dose of 3×10^{10} cm.$^{-2}$, which corresponds to a fission fragment dose of 1×10^7 recoils per cm.^{2} of crystal surface. Etching times and magnifications are given in the legends. A general view of the boundary of the bombarded region is shown in Fig. 1 and an expanded view of part of the boundary is shown in Fig. 2 at an earlier stage of the etching. From this latter photograph it may be calculated that the etch-pit density is 8–9 × 10^6 cm.$^{-2}$, from which it appears that one etch-pit is formed for each fission fragment after allowance is

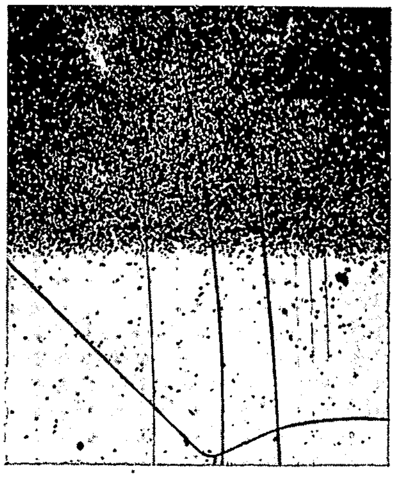

Fig. 1. General view of the boundary of the bombarded region. 32 min. etch. (× 60)

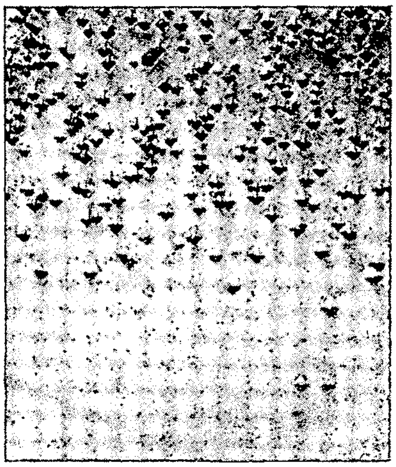

Fig. 2. Expanded view of a section of the boundary of the bombarded region. 8 min. etch. (× 640)

made for overlap. No new phenomena are introduced as the density of fission fragments is increased to 10^{12} cm.$^{-2}$, and at no stage has any effect of the ^{6}Li(n,α)^{3}H reaction been observed, though even in the photographed crystal some 10^8 n,α events cm.$^{-2}$ must have occurred within recoil range of the surface. Even heavily bombarded surfaces (10^{12} fission fragments per cm.^{2}) reveal no sputtering or surface structure before etching. So far as etching is concerned, the damage appears to anneal out completely between 450 and 500° C., as suggested by the results of Smallman and Willis[3]. There is no evidence of polygonization during gentler annealing treatments.

When small ($< 1\mu$), the etch pits grow more rapidly than when they are large, and commonly exhibit central depressions, as shown in the electron micrograph, Fig. 3*a*. Other electron micrographs, Figs. 3*b* and *c*, clearly show that the walls of the etch pits consist of finely spaced terraces and are not planar, the walls becoming steeper towards the centre of the pit. As the pits grow larger, the rate of linear growth is reduced. Two types of growth appear to be possible. Some pits remain fairly shallow over most of their area, but retain a central depression, whereas others, in the minority, grow as deep regular square pyramids throughout their lives. Examples of both types of growth are shown in Figs. 2 and 4. We therefore propose that in the case of etching recoil tracks, the initial process is a rapid dissolution of highly disordered material at the centre of the track. This rapid dissolution permits the development of crystal faces which are not necessarily those of lowest surface free energy though they have the correct symmetry for the {100} face. Rapid dissolution continues until the etch pit exceeds the boundary of the track, when the normal crystal structure determines the rate of dissolution and the angles at which the etch pit faces meet the surface. It is also of general interest to note that damage which may be etched is caused even by fission fragments at the commencement of their tracks. This means that we cannot assume, as is often done for energetic charged particles, that simple ionization predominates at the beginning of the track. Lattice displacements, albeit by mutual repulsion of highly ionized constituents, are important at the beginning of a fission fragment track.

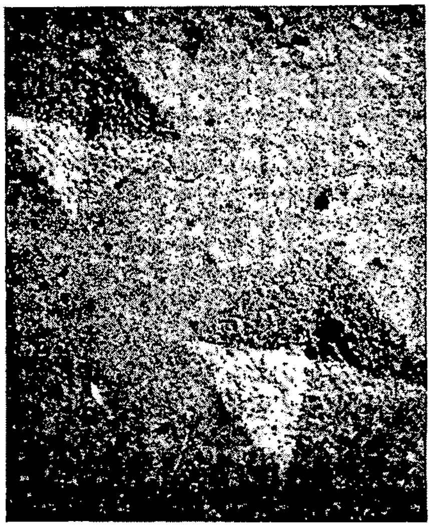

Fig. 3*a*. Electron micrograph of two typical pits. The replica was made of 'Formvar' shadowed normally with carbon and at 45° with palladium-gold. 1 min. etch. (× 13,300)

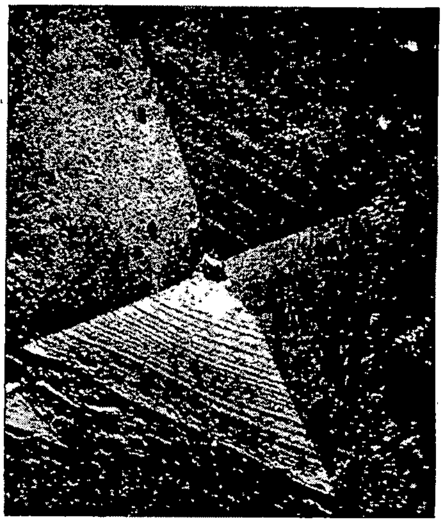

Fig. 3*b*. Electron micrograph of a small pit, showing the terraced faces. The cube directions are parallel to the etch pit diagonals. 1 min. etch. (× 13,300)

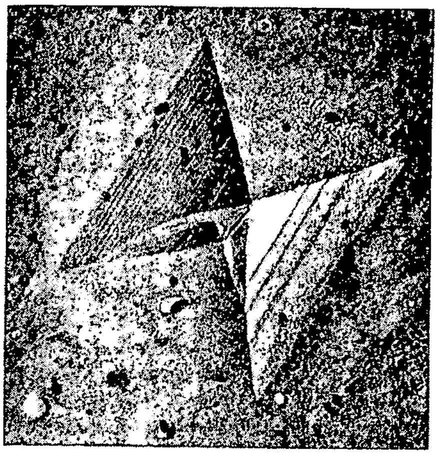

Fig. 3*c*. Electron micrograph of a twin pit showing terraced faces. 1 min. etch. (× 10,000)

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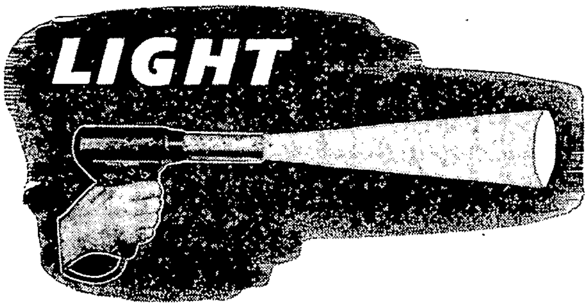

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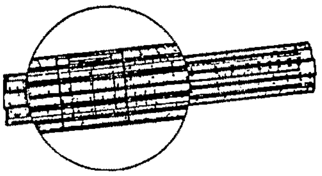

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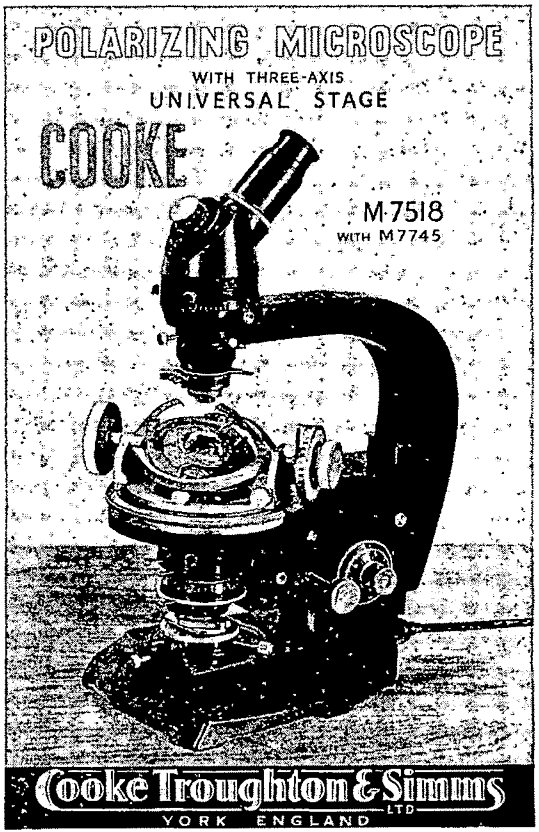

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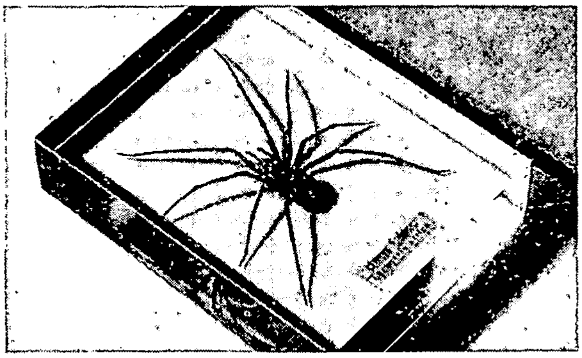

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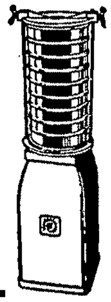

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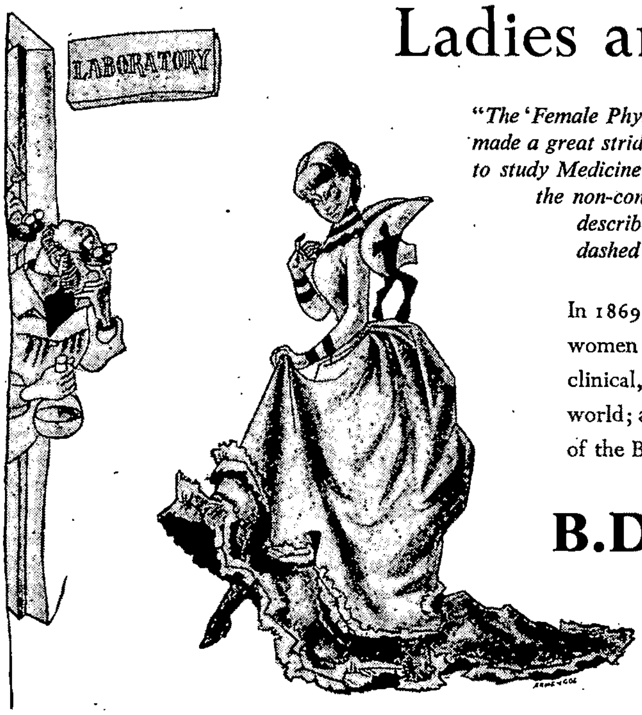

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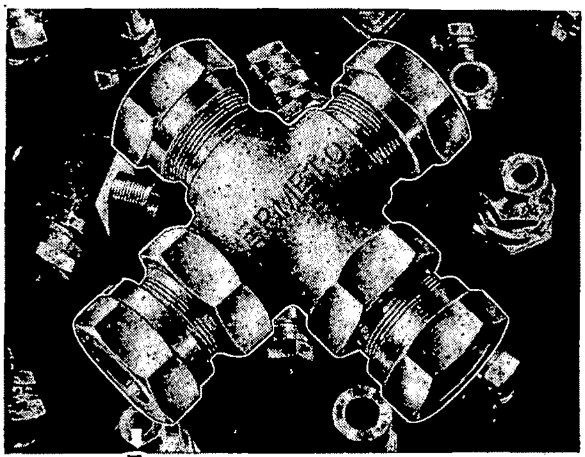

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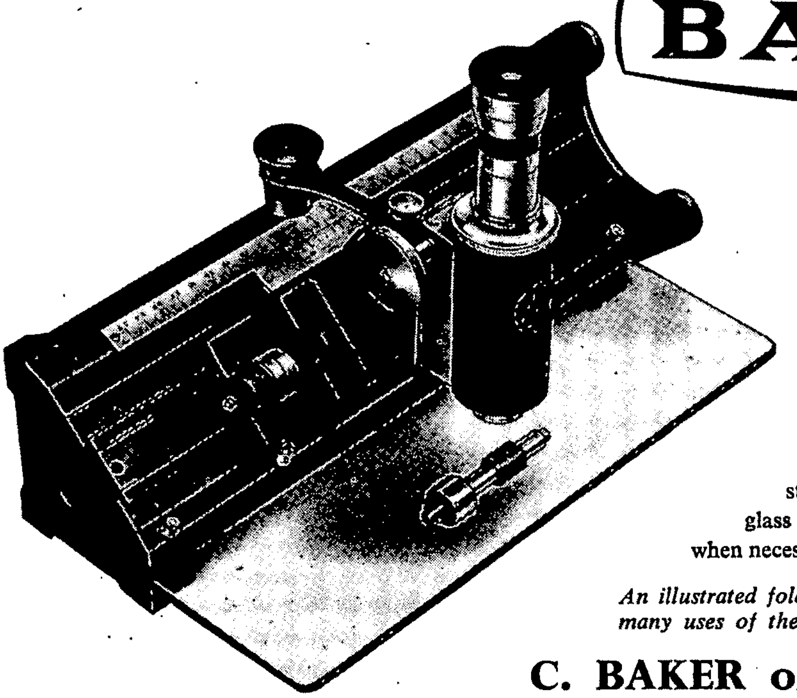

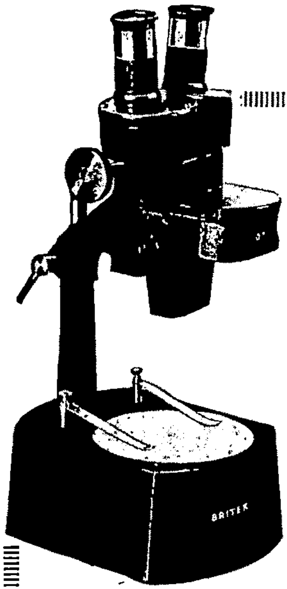

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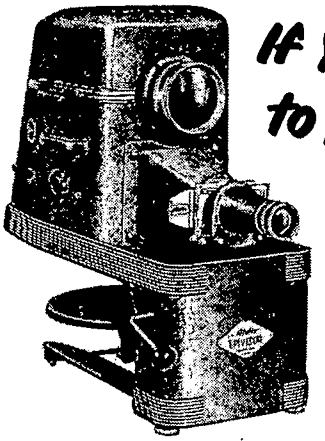

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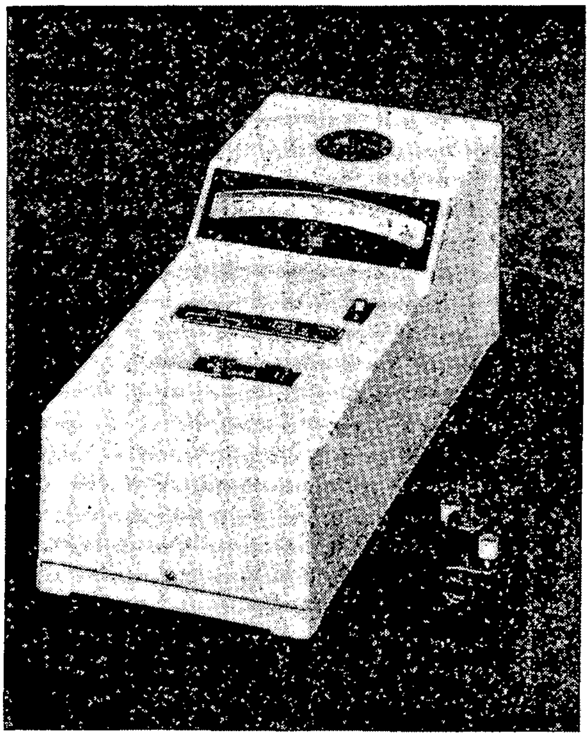

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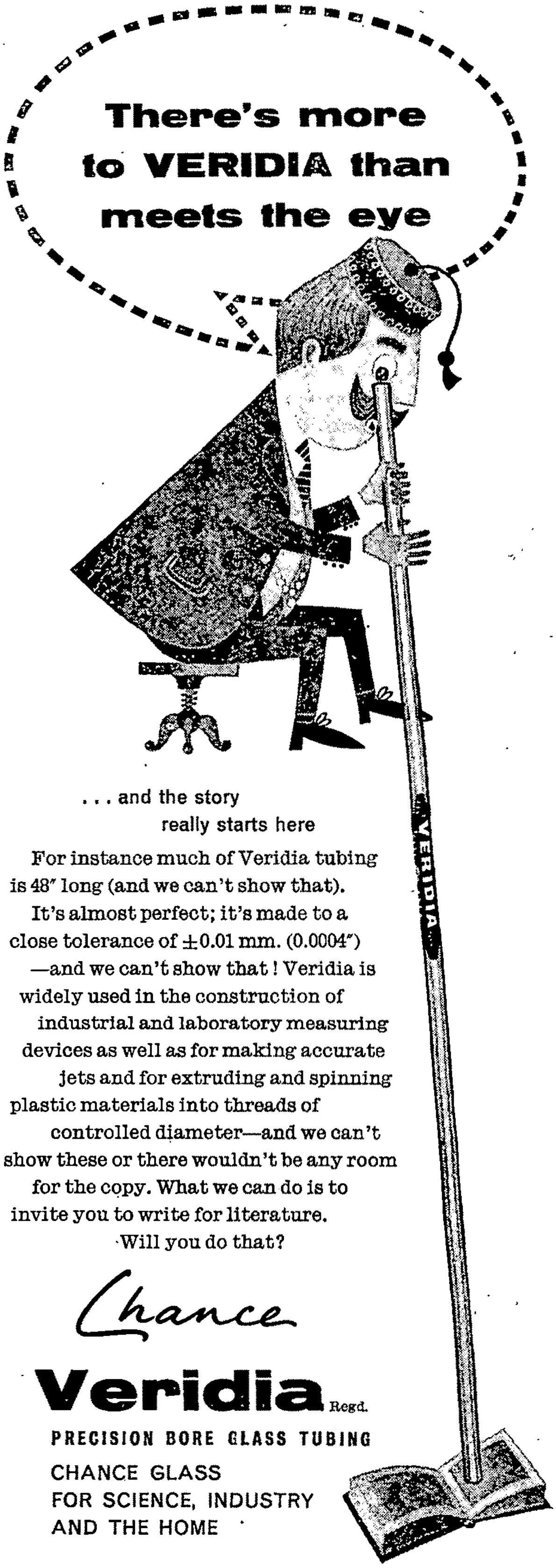
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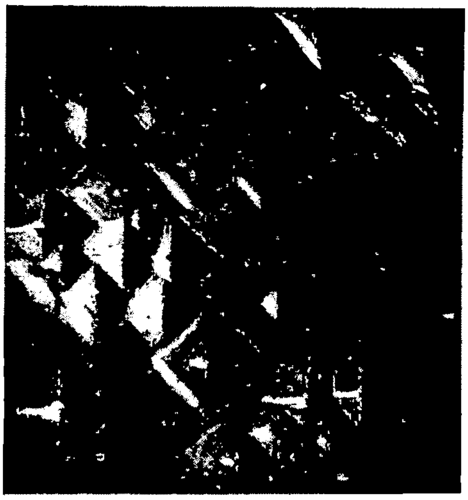

Fig. 4. Optical micrograph of the bombarded surface after soaking for 42 min. in the unstirred etch solution. (× 1,260)

If the above argument is qualitatively correct, the region of substantial lattice damage around the fission recoil track may reach a diameter of about 5000 A. in lithium fluoride. We conclude from the absence of polygonization and the low energy input, which is insufficient to raise the temperature of the surface layers even by 0·1° C., that classical dislocations are not formed in lithium fluoride by recoiling fission fragments and that we are dealing with linear regions of lattice damage, although in potassium bromide there is some evidence for the production of dislocations by this means.

A further development of interest is noted after prolonged soaking without agitation of the bombarded crystals in the etch solution. Fig. 4 is an optical micrograph (× 1,260) of etch pits developed in the unstirred reagent in 42 min. at 12° C. It will be seen that although some of the pits are regular square pyramids, others have developed a small number of pronounced steps. Similar pits have been observed by Whapham for etch pits originating on dislocations, and in explanation he has suggested that a dislocation inadvertently introduced during rough handling may become trapped at the centre of a flat pit formed at an earlier stage. This mechanism appears realistic in the case of flat-bottomed etch pits originating at dislocations which have afterwards moved on along a slip line, but can scarcely apply to pits originating at recoil tracks.

Noting that small, rapidly formed etch pits show a regular terraced structure, we propose that these terraces are probably composed of {100} planes parallel to the crystal surface and {110} planes normal to the crystal surface. On prolonged soaking the relative areas of these planes become redistributed in favour of decreasing {110} area even in the absence of overall dissolution. According to the estimates of van Zeggeren and Benson[4], the surface energies, not allowing for surface polarization, are 832 and 169 ergs cm.$^{-2}$ for the {110} and {100} faces, respectively. This is quite consistent with the view that a regular square pyramidal pit in contact with mother liquor is inherently unstable and will eventually break down into a large flat-bottomed pit containing a small pit at the centre.

I am indebted to Dr. W. M. Lomer and to Dr. A. D. Whapham for useful discussions. Mr. J. A. Coiley took the electron micrographs.

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EFFECT OF HYALURONIDASE ON CAPILLARY PERMEABILITY, LYMPH FLOW AND PASSAGE OF DYE-LABELLED PROTEIN FROM PLASMA TO LYMPH

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According to previous reports[1–3] hyaluronidase seems to exert a distinct effect on the capillaries, increasing their permeability. This assumption, however, is not definitely proved. Hæmoconcentration, increased loss of fluid and of injected dyestuff from the circulation produced by hyaluronidase can equally well be accounted for by intravascular pooling of blood plasma[4,5].

Proteins leaving the circulation appear in the extravascular fluid. Tissue fluid, which forms the greater part of the extravascular fluid, can, under normal conditions, scarcely if ever be collected in sufficient amounts for analysis. Colloidal molecules entering the extracellular fluid also appear almost instantaneously in the lymph. We hoped, therefore, to obtain further information on the effect of hyaluronidase by investigating the composition and flow of lymph.

All investigations were carried out on dogs under hexobarbital anæsthesia (0·1 gm./kgm.). In the first series we tapped the thoracic duct in the neck and also the cervical lymph trunks on both sides with plastic tubes. In the second series of investigations lymph was collected from the lymphatics of the liver and the small intestine. The dogs received 1,000 V.R.U. of bacterial hyaluronidase (Hyason Organon) intravenously, followed immediately by 0·1 ml./kgm. of a 0·1 per cent solution of Evans blue, also intravenously. Lymph was collected for three periods of 15 min. each before the administration of hyaluronid-

Table 1. Effect of Hyaluronidase on Arterial Blood Hæmatocrit and Total Plasma Protein

		Before	After hyaluronidase (min.)					P_{5-95} (per cent)
			5	15	30	60	90	
Arterial blood hæmatocrit (18 cases)	$\bar{x}$	42·5	46·5	46·7	46·7	47·1	46·4	< 5
	s	6·67	7·32	7·20	6·23	6·23	6·50	
Total plasma protein (10 cases)	$\bar{x}$	6·33	6·42	6·50	6·30	6·27	6·22	> 90
	s	0·69	0·50	0·49	0·61	0·62	0·69	

$\bar{x}$, mean ; s, standard deviation.

Table 2. Effect of Hyaluronidase on Lymph Flow

	Controls mgm./min.	Time after hyaluronidase (min.)							
		0–15		15–30		30–60		60–90	
		mgm./min./per cent*		mgm./min./per cent*		mgm./min./per cent*		mgm./min./per cent*	
Thoracic duct									
n	8	8	8	8	8	8	8	8	8
x	463	1,113	+ 145	769	+ 70	589	+ 45	619	+ 53
s	330	764	88	564	56	413	65	446	58
P			< 0·1		~ 2		> 5		< 5
Liver lymph									
n	10	10	10	10	10	10	10	10	9
x	87	161	+ 88	113	+ 35	86	− 2	88	+ 2
s	69	151	54	99	35	90	46	92	47
P			< 0·1		~ 1		> 70		> 20
Intestinal lymph									
n	11	11	11	11	11	11	11	11	11
x	61	96	+ 63	79	+ 29	63	+ 10	62	+ 4
s	86	146	52	137	49	106	64	113	60
P			< 1		> 5		~ 60		~ 40

* Percentage increase in lymph flow.
n, Number of data available ; x mean ; s, standard deviation ; P, percentage probability (Student's t test).

ase and afterwards for four further periods ; the first two of 15 min., the others of 30 min. Lymph flow, the concentration of Evans blue in lymph and plasma, arterial blood hæmatocrit, and the concentration of total protein in plasma and lymph were determined before and after administration of hyaluronidase.

Hyaluronidase produced a small but significant rise of the arterial blood hæmatocrit in all experiments, but there was no significant change in total protein concentration of the plasma (Table 1).

Lymph flow increased in all vessels investigated. The most marked increase of flow-rate was recorded in the thoracic duct ; there was also an increase of lymph flow from the liver and the intestines (Table 2). An analysis of the results showed that the increase of lymph flow was statistically significant if expressed as percentage of that before administration of hyaluronidase.

The disappearance of Evans blue from the circulation and the appearance of the dye in the lymph was enhanced by hyaluronidase. It has been shown that this dye is quite firmly bound to protein *in vitro*[6,7] and *in vivo*[8,9]. Therefore, we believe that the passage of dye from plasma to lymph marks that of the protein it labels. To confirm this assumption we investigated simultaneously the disappearance from the plasma and the equilibrium between plasma and lymph of Evans blue and dextran (mean molecular weight, 60,000) and also of human serum albumin labelled with iodine-131[4,5,10], and found a good agreement between the different substances. The disappearance of the labelled protein was estimated by the following equation[11] :

$$k = \frac{\ln (V_1C_1) - \ln (V_2C_2)}{T_2 - T_1}$$

where k is the fraction of dye (labelled protein) disappearing from plasma per min. ; V_1 is the plasma volume before administration of hyaluronidase, V_2 the plasma volume 90 min. after administration of hyaluronidase, C_1 and C_2 the concentrations of dye in plasma and T_1 and T_2 the times of drawing the respective specimens of plasma. Hyaluronidase produced a definite increase in the amount of dye disappearing from plasma. In eighteen normal controls this was 0·00225 (standard deviation 0·000827) ; after hyaluronidase administration (in

Table 3. Effect of Hyaluronidase on Equilibration of Labelled Protein between Plasma and Lymph

Min.	Thoracic duct				Liver lymph				Intestinal lymph			
	0–15	15–30	30–60	60–90	0–15	15–30	30–60	60–90	0–15	15–30	30–60	60–90
Controls												
n	7	7	7	7	6	6	5	5	5	6	6	5
$\bar{x}$	15·4	35·1	43·6	60·1	16·0	34·5	45·4	60·0	7·8	28·8	54·5	59·2
s	8·3	26·6	25·9	35·2	11·4	15·6	14·3	10·0	3·9	12·4	24·5	27·2
Hyason												
n	8	8	8	8	9	9	9	8	8	8	8	8
$\bar{x}$	51·3	63·6	67·6	62·0	29·3	55·7	69·2	77·1	20·1	37·8	50·9	60·6
s	20·0	11·4	14·2	13·9	20·9	23·7	21·1	16·0	12·3	15·5	16·6	17·9
d*	3·63	2·63	2·18	0·13	2·58	2·09	2·50	2·37	2·62	1·20	0·31	0·10
P	<1	<5	>5	>90	≈5	>5	≈5	>5	<5	>20	>70	>90

* Behren's d test.
n, Number of cases ; $\bar{x}$, mean of percentage relative concentration of dye in lymph and plasma ; s, standard deviation ; P, percentage probability.

Table 4. EFFECT OF HYALURONIDASE ON THE PROTEIN CONTENT OF LYMPH

		Before	Time after hyaluronidase (min.)				P*
			0–15	15–30	30–60	60–90	
Thoracic duct	$\bar{x}$	5·10	5·10	5·25	5·27	5·31	> 90
(7 cases)	s	0·92	0·86	0·83	0·73	0·95	
Hepatic lymph	$\bar{x}$	5·40	5·51	5·55	5·48	5·57	> 70
(8 cases)	s	1·11	0·83	0·79	0·76	0·94	
Intestinal lymph	$\bar{x}$	4·53	4·71	4·87	4·97	4·84	~ 20
(7 cases)	s	0·82	0·76	0·51	0·84	0·59	

$\bar{x}$, Mean; s, standard deviation.
* All values after administration of hyaluronidase pooled.

thirteen dogs) this rose to be 0·00333 (standard deviation 0·000655). The difference is highly significant ($P < 0·001$).

We also investigated the equilibrium of labelled protein between blood and lymph. As a convenient way of expressing the passage of labelled protein, the concentration of dye in the lymph was calculated as a percentage of the mean plasma concentration. Table 3 shows a significant increase of relative concentration in the lymph of all the vessels investigated. We were, however, unable to collect sufficient amounts of lymph for estimation of dye concentration in the cervical duct, but we gained the impression that cervical lymph also contains more dye after injection of hyaluronidase.

Finally, there was a small non-significant increase in the total protein concentration in the lymph (Table 4).

This evidence, in agreement with the findings of other workers, leaves no doubt that the permeability of the capillaries is increased by hyaluronidase. There is not only an increased leakage of dye, but after administration of hyaluronidase the transfer of labelled protein between plasma and lymph is also enhanced. Furthermore, there is a definite increase in lymph flow. All these findings point to an increased protein and fluid transfer from the capillaries to the extracellular fluid. The increase of capillary permeability is quite general and could be detected in all the areas studied. The effect of hyaluronidase is of short duration only.

It is interesting that there were no significant changes in the total protein content of the lymph. The maximum concentration of Evans blue in the lymph was identical in the dogs receiving hyaluronidase and in the untreated controls. Although, in the short experimental period, equilibrium between plasma and lymph was not attained, towards the end of this period there was no significant difference of relative dye concentrations between the controls and the treated animals. These results point to the further possibility that a moderate increase of capillary permeability—in spite of a marked protein leakage—does not necessarily increase the protein content of lymph, nor perhaps that of the tissue fluid. The protein leaving the capillaries, if it does not exceed a certain amount, can be cleared from the extracellular compartment by the increase of the lymph flow alone, without increasing the protein concentration in the lymph.

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GRAVIMORPHISM IN TREES

Effects of Gravity on Growth, Apical Dominance and Flowering in Fruit Trees

IT has long been claimed by horticulturalists that downward training of the branches of fruit trees reduces vegetative growth and promotes flowering[1–4]. These reports suggest that the position of the shoot in relation to the gravitational field may affect growth and flowering, but there appear to have been very few rigorous investigations of these effects in trees. A detailed investigation of the effects of gravity on growth, apical dominance and flowering in fruit trees was accordingly commenced in 1956.

The effect of the orientation of the shoot on its growth was investigated in apples, cherries, plums and blackcurrants, using 'maiden' trees planted in pots and restricted to a single shoot in the second year. The growth of trees maintained horizontally throughout the growing season was compared with that of the vertical controls for each species. The horizontal position was obtained by placing the whole plants and their pots horizontally. One group of horizontal plants was maintained with the same side of the plant uppermost throughout the period of treatment, while the plants of a second group were rotated through 180° twice each day. The treatments were commenced shortly before bud expansion in the spring. For watering, the horizontal plants were placed erect for 1–2 minutes, as required; to eliminate possible differential effects due to rain, the soil surface of the pots of the vertical series was covered with polyethylene sheeting. In order to maintain the experimental material as uniform as possible, all lateral shoots were removed as they emerged. In blackcurrant, there was a marked tendency for the outgrowth of laterals from the upper side of the stem, as has also been reported for citrus[5]. The extension growth was measured weekly throughout the growing season and the mean total extension-growth for the various experimental groups is given in Table 1.

In all species, the total growth of the horizontal trees was markedly less than that of the vertical controls, and the effect of the horizontal position was accentuated when the plants were rotated. In the cherries and plums the reduced total growth was due both to a smaller number of internodes and to reduced internode length, in the horizontal trees. In the apples and blackcurrants the difference in extension-growth was mainly due to differences in internode-length. Reduced hypocotyl extension in inverted seedlings of various species was reported by Hering[6].

Table 1. EFFECT OF SHOOT POSITION ON EXTENSION GROWTH

Species and treatment	No. of plants	Mean extension growth (cm.)	Mean inter-length (cm.)	Mean No. of inter-nodes
Cherry, Mazzard *F*12/1				
Horizontal, rotated	16	15·4 ± 1·4*	1·3	12
Horizontal, non-rotated	16	21·4 ± 1·7	1·5	14
Vertical	16	51·8 ± 2·1	2·5	21
Apple rootstock, No. 3436				
Horizontal, rotated	19	46·9 ± 1·5	1·4	32
Horizontal, non-rotated	19	52·9 ± 2·1	1·7	31
Vertical	19	69·3 ± 2·1	2·1	33

* Standard error.

A number of experiments has been conducted to investigate the interaction between apical dominance and the effects of gravity, and the results of two such experiments are given in Table 2. In these experiments, one-year stool-bed layers of apple rootstock *MM* 111 were pruned back to a height of 24 inches, and the subsequent growth was restricted to the laterals from the uppermost three buds. The resulting lateral shoots were trained as indicated.

From the results it is apparent that the growth of all shoots is less when they are in a horizontal position as compared with the vertical, but the uppermost shoots show a greater percentage reduction when trained horizontally than do the lower shoots (Experiment 1). As a result, there is relatively little difference in growth of the three shoots when they are all trained horizontally, so that only slight apical dominance is manifested. On the other hand, when all the shoots are trained vertically, the greater growth of the uppermost shoots results in well-marked apical dominance. Thus, it appears that the apical dominance exhibited by the uppermost shoot is only manifested when it occupies a vertical position. Since the lateral shoots usually grow out at an angle removed from the vertical, this will tend to reduce their growth further and to accentuate the apical dominance of the vertical leader.

The orientation of the shoot also has a marked effect on flower-initiation in apple rootstock No. 3436. None of the one-year maiden apple layers used in the experiment on extension-growth, described above, initiated flowers in 1956. The treatments were continued with the second year, however, and marked differences in flower-initiation were then observed. The 2-year-old layers grown in the normal vertical position initiated relatively few flowers, but the layers grown horizontally, both 'rotated' and 'non-rotated', showed heavy flowering on both 'spurs' of the 2-year shoots and also on the 1-year shoots (Table 3). The vertical trees, instead of forming spur-shoots on the 2-year shoots, formed short lateral vegetative shoots. Thus, the orientation of the shoot in relation to gravity has a marked effect on flower-initiation in apple. Similar effects were observed also in cherries, although the number of flowering buds was much smaller than in apples (Table 3). Effects of gravity on flower-initiation have also been reported for pineapple[7] and soybeans[8].

Table 2. EFFECT OF GRAVITY ON APICAL DOMINANCE

	Lateral No.	Shoot position*	No. of plants	Mean extension growth (cm.)
Exp. 1	1st	*V*	12	66·2 ± 2·6
	2nd	*V*		58·4 ± 3·4
	3rd	*V*		50·2 ± 3·1
	1st	*H*	12	42·4 ± 2·0
	2nd	*H*		40·6 ± 1·6
	3rd	*H*		39·6 ± 2·3
Exp. 2	1st	*V*	10	44·0 ± 2·0
	2nd	*V*		33·4 ± 3·4
	3rd	*V*		30·7 ± 1·5
	1st	*V*	8	49·2 ± 7·2
	2nd	*H*		26·8 ± 2·3
	3rd	*H*		27·3 ± 2·9

* *V*, vertical; *H*, horizontal.

Table 3. EFFECT OF GRAVITY ON FLOWERING

Species and treatment	No. of plants	No. of flowering buds	
		2-yr. shoots	1-yr. shoots
Apple rootstock No. 3436			
Horizontal, rotated	19	40	76
Horizontal, non-rotated	19	63	98
Vertical	19	1	4
Cherry, Mazzard *F*12/1			
Horizontal, rotated	16	1	0
Horizontal, non-rotated	16	19	0
Vertical	16	0	0

These effects of gravity on growth and flowering are clearly related to geotropism. Since, however, the latter term is used to describe a growth curvature, it is not strictly appropriate for the phenomena reported here, for which it is proposed to introduce the term 'gravimorphism'.

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Effect of Gravity on Flowering and Shoot Growth in Japanese Larch (*Larix leptolepis*, Murray)

PARALLEL with the investigation into the effects of gravity on growth and flowering of fruit trees[1], a series of experiments is also being carried out with forest trees. Species of *Pinus*, *Larix*, *Fagus* and *Betula* are being studied, but the present report deals chiefly with Japanese larch (*Larix leptolepis*, Murray).

While for fruit trees there is a certain amount of evidence from the experience of horticulturalists that gravitational effects may be of importance, there is little suggestion in the literature that this applies also to forest trees. However, Matthews and Mitchell[2], working on methods of training forest trees for heavy seed production, record that "nine-year-old Japanese and hybrid larch treated to form espaliers produced a great density of male and female flowers".

In order to investigate rigorously whether the actual position of the shoot relative to gravity influences the flowering of Japanese larch, an experiment was carried out in which branches were trained into horizontal and into downwardly directed positions, an equivalent branch in the same 'whorl' being left in its natural upwardly curving ('upswept') position as a control. In some cases a further branch was fixed in its existing position to prevent any tendency to sag during the course of the experiment. The treatments were applied between the end of March and the end of April 1957 to 2–5-year-old branches on trees 10–12 years old which had not up to that time borne an appreciable number of flowers.

By autumn 1957 the flower buds for 1958 were clearly visible, and it was found that out of 12 treated trees 10 showed more flowering in horizontal and particularly in downwardly directed treatments than in the controls, the difference being very marked in 8 trees. As many as 200 flowers, mainly male but including some female, had been induced on some branches, compared with three or four flowers on the untreated branch. The remaining two trees did not flower at all, possibly because they were smaller than average. They are excluded from Table 1, as is one other tree which started flowering heavily in 1958 in any event.

Table 1. EFFECT OF GRAVITY ON FLOWERING IN JAPANESE LARCH

	Branch fixed in existing position	Control branch (unfixed)	Branch fixed in horizontal position	Branch fixed in downwardly directed position
Total number of flower buds	21	90	647	1,079
No. of branches involved	11	16	13	12
Average number of flower buds per branch	2	5·5	50	90

The flowering of young Japanese larch is thus markedly influenced by the position of the branches in relation to the gravitational field, the greater the branch angle (measured from vertically upwards) the heavier the flowering. In addition, the trees have been brought into heavy flowering at an age when they would normally bear few or no flowers.

It seems probable that this 'gravimorphic' effect is important also in the normal reproductive development of larch. It is well known that in trees of many species the vigorously growing young branches are upwardly directed, generally growing out at an angle which is characteristic of both the species and the individual tree. With increasing age, the branch angle usually becomes greater so that the branch often comes to assume a horizontal or even downswept position, no doubt partly or wholly due to its increasing weight. From the results of the foregoing experiment it seems clear that this natural change in branch angle will tend to favour the onset of the flowering phase in young trees. Further evidence in support of this view is seen in the fact that the unfixed control branches generally had appreciably more flowers than those branches which were fixed in their existing position at the beginning of the season. It was also noted that in trees with a naturally flatter type of branching, the unfixed controls generally bore more flowers than in trees where the branches were very upswept.

In addition to inducing flowering, the horizontal and downwardly directed training in the foregoing experiment markedly reduced extension growth during 1957. Table 2 gives the measurements for the leading shoots of the branches.

Similar marked reduction in extension growth was produced in birch (*Betula verrucosa*, Ehrh.) by pulling down individual branches.

Table 2. EFFECT OF GRAVITY ON EXTENSION GROWTH IN JAPANESE LARCH
(Means of 11 branches)

	Control branch (unfixed)	Branch fixed in horizontal position	Branch fixed in downwardly directed position
Mean extension growth of main branch axis (cm.)	29·5 ± 2·3*	17·5 ± 1·5	14·0 ± 1·6
As a per cent of control branch	100	59·5	47·5

* Standard error of mean.

Gravity appears also to affect the distribution of flower buds on the individual larch twig. They may be seen to occur mainly on the lower sides of horizontally inclined twigs, and on all sides of the trailing twigs which are frequently found in this species. Now since the buds point forwards on the twigs at an angle of approximately 60–70° it would be expected that the flower buds on these horizontal and trailing twigs would point either downwards or horizontally, but not upwards. Quantitative verification of the observed distribution of flower buds can therefore be obtained by measuring the direction in which a large number of flower buds point in relation to gravity. Table 3 gives the results for two 5-year-old branches taken from trees which had recently commenced flowering.

Table 3. DISTRIBUTION OF MALE FLOWER BUDS IN RELATION TO GRAVITY

Direction in which buds point	Angle (measured from vertically upwards)	Branch 1		Branch 2	
		No. of flower buds	Per cent	No. of flower buds	Per cent
Upwards	0° –22½°	—	—	—	—
½ up	22½°–67½°	2	1	5	3
Horizontally	67½°–112½°	48	30	49	31
½ down	112½°–157½°	77	47	82	52
Downwards	157½°–180°	36	22	23	14
		163	100	159	100

It is seen that an average of 98 per cent of the flower buds point either downwards or horizontally. Although this confirms the observation that there is a clear-cut zoning of the flower buds to loci in which they will point downwards or horizontally, it is not yet clear whether the response of the bud is directly determined by its own orientation in relation to gravity, or whether it is determined by the position of the twig or branch system on which it occurs.

In view of the generally accepted evidence that geotropic effects result from the differential distribution of growth-hormone in response to gravitational stimuli, a similar mechanism for these 'gravimorphic' effects may be expected. This problem is being investigated.[1]

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LETTERS TO THE EDITORS

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Polar Wandering, a Random Walk Problem

It has often been supposed that due to redistributions of mass the body of the Earth as a whole has shifted relative to its rotational axis, which has remained fixed relative to the Sun. It is convenient to think of this as movement of the pole over the surface of a fixed Earth. Since the Proterozoic the pole appears to have been displaced by as much as 90° of arc to its present position. Orogenic or epeirogenic movements and ice-cap melting or formation with the attendant fluctuations in sea-level are usually cited as possible causes of polar wandering. Darwin[1] and Kelvin[2] first discussed the dynamic stability of the Earth. Gold[3] and Munk[4] have recently re-examined the problem and have concluded that such large displacements of the pole could be a consequence of such geological activities.

The position of the pole may be obtained from the average direction of remanent magnetization of rock formations when the hypothesis[5] is made that the Earth's magnetic field, when averaged over a few thousand years, has approximated to a geocentric axial dipole. It has been customary to connect these pole positions[6] by curves passing from the Pacific Ocean along the east coast of Asia to the position of the present pole. But since the geological events which may have been responsible for polar wandering have been irregular, both in their type and in their distribution and timing, they are likely to have produced random polar movements. In this communication an attempt is made to fit the palæomagnetic data to a random walk of the pole over the Earth's surface.

If the sampling area has undergone continental drift, the polar wandering rate would have the drift velocity superimposed upon it, and both would be present in the palæomagnetic data. In this work the pole paths relative to Europe and North America have been used because their similarity in shape and direction suggests that neither continent has been displaced in latitude relative to the other to any great extent, but it has to be borne in mind that errors may arise from this source. The simplest case of a random walk is that on a plane, and provided the individual displacements are small and the total displacement does not greatly exceed 90° of arc it is not essentially different from a random walk on a sphere.

The probability density $w(\psi)$ that the pole will have an angular displacement ψ from the present pole at a time t is given by:

$$w(\psi) = \frac{2\psi}{C^2kt} \exp\left(-\frac{\psi^2}{C^2kt}\right) \qquad (1)$$

where C^2 is the mean square of the individual steps in the walk and k is the number of steps per unit time. The mean value of the angular displacement at time t is given by:

$$\int_0^\infty \psi\, w(\psi)\, d\psi \qquad (2)$$

$$= \int_0^\infty \frac{2\psi^2}{C^2kt} \exp\left(-\frac{\psi^2}{C^2kt}\right) d\psi \qquad (3)$$

$$= \tfrac{1}{2}\, \pi^{1/2}\, C(kt)^{1/2} \qquad (4)$$

and the mean value of the square of the displacement is C^2kt. Thus ψ is expected to vary linearly with $(kt)^{1\cdot 2}$ and points, the co-ordinates of which are $(\psi, t^{1/2})$, will be scattered along the line $\psi = C(kt)^{1/2}$. The limits for ψ at a probability of 0·95 are:

$$\psi_u = \varepsilon_u C(kt)^{1/2} \qquad (5a)$$

$$\psi_e = \varepsilon_e C(kt)^{1/2} \qquad (5b)$$

where the factors ε_u and ε_e are given by:

$$0{\cdot}025 = \exp(-\varepsilon_u^2)$$

and

$$0{\cdot}975 = \exp(-\varepsilon_e^2)$$

respectively. Thus ψ lies between the limits 1·92 $C(kt)^{1/2}$ and 0·16 $C(kt)^{1/2}$ at $P = 0{\cdot}95$.

In Fig. 1 the displacements are plotted against the square root of time, the results from Western Europe and North America being indicated by full and open circles, respectively. The straight line through the origin which best fits these data by least squares is given by

$$\psi = 3{\cdot}0\, t^{1/2} \qquad (6)$$

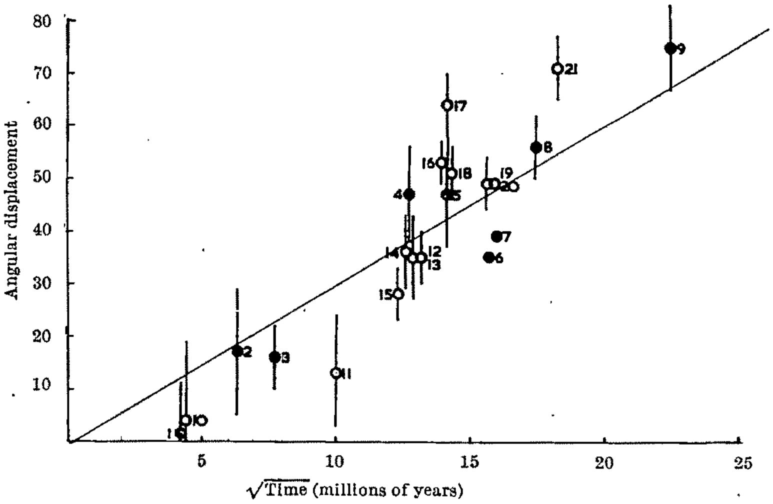

Fig. 1. The angular displacement of the pole from its present-day position is plotted against the square root of time in millions of years. The pole positions used are numbered as follows: 1, Miocene lava, France; 2, Oligocene intrusives, France; 3, Eocene lavas, Northern Ireland; 4, Triassic marls, England; 5, Permian traps, Exeter; 6, Carboniferous millstones, Derbyshire; 7, Carboniferous toadstones, Derbyshire; 8, Devonian sandstones, Wales; 9, Cambrian sandstones, Wales; 10, Upper Tertiary lavas, Washington; 11, Cretaceous sandstones, Colorado plateau; 12, Triassic sandstones, Springdale; 13, Triassic lavas, Holyoke; 14, Triassic lavas, sediments, Connecticut; 15, Triassic sequence, New Jersey; 16–18, Permian Supai beds, Arizona; 19, Carboniferous sandstones, Arizona; 20, Carboniferous concretion, Texas; 21, Silurian sediments, Maryland. The vertical lines through the pole positions represent the error (at $P = 0{\cdot}05$) in determining the latitude. The European and North American results are indicated by full and open circles respectively

where ψ is in degrees of arc and t is in millions of years. The expected value of 3° of arc for the magnitude of the displacement of the pole in one million years is a useful quantitative value for other workers interested in the mechanism of polar wander.

It is emphasized that since the movement of the pole may be considered to be a random walk, there will be, on one hand, periods during which there is effectively very little displacement of the pole (for example, the Quaternary) and, on the other hand, periods during which rapid displacement of the pole is in evidence (for example, Carboniferous[7]).

This work was carried out while I was a research student in the Department of Geophysics of the Australian National University at Canberra, A.C.T. I wish to thank my supervisors, Prof. J. C. Jaeger and Mr. E. Irving, for their criticism and helpful discussion.

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Secular Variation in the Direction of Geomagnetism as the Standard Scale for Geomagnetochronology in Japan

It is well known that igneous rocks and ceramic objects are permanently magnetized in the direction of the Earth's magnetic field in which they were cooled from a high temperature. I have already pointed out that the baked earth in the hearths of prehistoric dwelling pits would be magnetized similarly, and that this could be applied to developing chronology for anthropology and archæology[1]. The term 'geomagnetochronology' may be defined as chronology from palæomagnetism.

In Japan three kinds of sources—hearths, furnaces and kilns—offer baked earth of various ages. A hearth is a simple fireplace made directly on the floor of a prehistoric dwelling pit, a furnace is a structure built up with sandy clay against the wall of a dwelling pit of the protohistoric and the historic ages, while a kiln is an ascending tunnel-like structure built with clay on the slope of a hill, in which ceramic wares were baked in historic times.

Samples of small blocks of baked earth, generally about ten in number, were collected from each fireplace and the remanent magnetism was measured with an astatic magnetometer. The mean direction of the remanent magnetism of each set was calculated by Fisher's method[2], and for comparison the data from samples from sites far from Tokyo were reduced to Tokyo by Nagata's procedure[3].

The samples can then be dated by comparing the direction of the remanent magnetism with a standard scale of the secular variation in the direction of geomagnetism in the past; thus it is essential to establish such a standard scale. This standard scale has been set up for the past 1,700 years and it is shown in Fig. 1. Encircled points indicate the geomagnetic inclination and the geomagnetic declination at known dates, most of which were reported or cited by Nagata and Kato[4]. Old records of geomagnetic observations gave the points 1613, 1694, 1802, 1827, 1854, 1860, 1887, and the curves from 1887 to the present, while measurements of the remanent magnetism of lava-flows dated by the descriptions of volcanic eruptions of 864, 1471, 1749, 1778 and 1779 in old documents gave the other encircled points. Besides these, points 1 and 2 represent the direction measured by me for samples of baked earth from two kilns, the dates of which are almost certainly known from the type of pottery as about 1300. These gave the curve of inclination for the period from 864 to the present shown in Fig. 1; the curve was then extrapolated for the time before 864 on the assumption that the inclination underwent a secular variation similar to that estimated for the period after 864. On this curve were plotted the inclinations obtained from sixty-five sets of samples of baked earth from hearths, furnaces and kilns of various ages; eighteen of these are shown as points 3–20. The declinations associated with these inclinations were then plotted, and the secular variation curve of declination shown in Fig. 1 was drawn so as to fit as many as possible of the points. The vertical lines at each point indicate the magnitude of the Fisher radius of the circle of confidence at the 5 per cent level.

Three sets of samples which yielded points well off the curves have been ignored for the present. The two curves thus obtained seem to be reasonably accurate, since almost all the points are in general

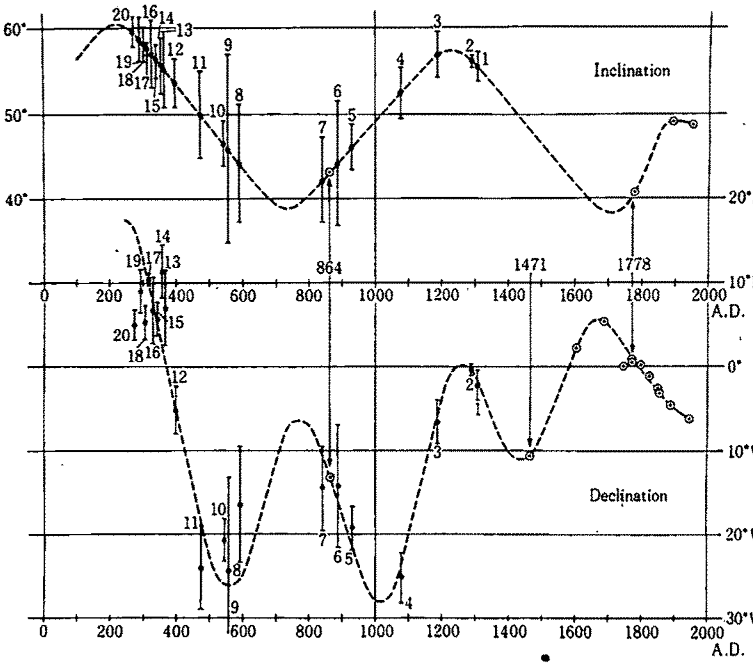

Fig. 1

Table 1

No. of samples	Declination D	Inclination I	Fisher's θ for $P = 0{\cdot}05$	Radiocarbon date
12	5·1° E.	49·2°	3·3°	4,546±220 B.P.
14	3·7° E.	50·6°	1·2°	5,100±400 B.P.
15	5·6° W.	48·2°	2·9°	
20	6·1° W.	48·9°	3·2°	

chronologically consistent with archæological evidence.

Although we have no specimens from before 864 which can be dated from records, radiocarbon assay can be used instead. At present two such assays are available for prehistoric Japan. One is that made by Libby, of the University of Chicago, on charcoal found on the floor of a dwelling pit at the shell-mound of Ubayama in the Chiba Prefecture[5]. I collected samples of baked earth from the floor of this dwelling pit and measured their remanent magnetism. The other radiocarbon date was obtained by Crane, of the University of Michigan, from a canoe excavated from a peat formation at Kamo in the Chiba Prefecture[6]. In this case there was no baked earth at the site, but I used samples from hearths of three dwelling pits which contained the same type of pottery as that associated with the canoe. These were at the shell-mound of Minamihori in the Kanagawa Prefecture. The results are presented in Table 1.

In 114 sets of samples of various ages during the past 6,000 years or so, the direction of remanent magnetism generally fell within the range 40–60° for the inclination, and 20° E.–30° W. for the declination. This suggests that the secular variation in the direction of geomagnetism for the past 6,000 years is similar to that estimated for the past 1,700 years. Assuming this, the most probable secular variation curves of the direction of geomagnetism for a time range covering 4,546 and 5,100 years before the present were tentatively drawn as in Fig. 2. On these curves the results of twenty-four measurements on baked earth from hearths fell in positions consistent with the chronological order known from the types of pottery associated with them. One result, however, was well off the curve.

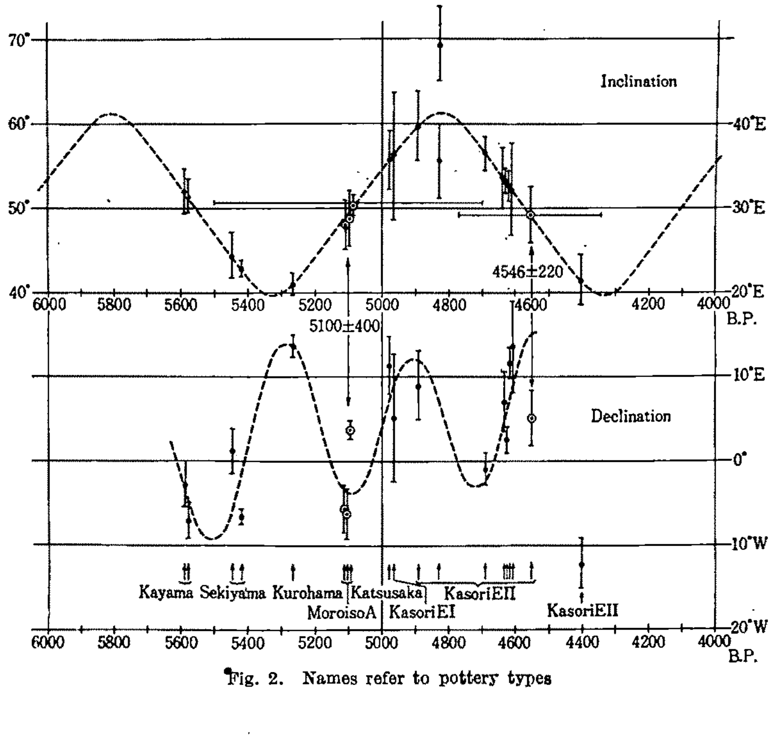

Fig. 2. Names refer to pottery types

A detailed account of this work will be published in *Journal of the Faculty of Science*, University of Tokyo.

My thanks are due to Prof. T. Nagata and the staff of the Department of Geophysics of the University of Tokyo, and Prof. Y. Kato of the Tohoku University for advice and assistance.

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Measurement of the Thickness of the Earth's Crust in the Albertan Plains of Western Canada

As a contribution to the International Geophysical Year, a group composed of Canadian, American and British oil interests and independent geophysical contractors has recently carried out a large-scale seismic refraction experiment in order to measure the thickness of the Earth's crust, or depth to the Mohorovičić discontinuity, in the Albertan Plains of western Canada.

Fifteen seismic parties using refraction equipment were spaced at roughly uniform intervals over a distance of 130 km. and two-way observations were made from 900-lb. buried charges of dynamite located at the extremities of this range. The line extended approximately parallel to the frontal thrust of the Rocky Mountains, between latitudes 50° 45′ N. and 51° 47′ N., and some 100 km. to the east of the thrust.

For the upper crustal material recorded as first events in both directions of shooting, the velocities were about 3·5 and 6·0 km./sec. The first represents Cretaceous shales and sands to a depth of 2·3 km. The second velocity represents the known Palæozoic limestones, and its event carried for the whole length of the line.

A later event with the characteristic time-distance relation of a reflexion shows a marked increase in energy content at a distance not less than about 100 km. where its velocity is about 8·2 km./sec. This event has been ascribed to reflexions from the Mohorovičić discontinuity amplified by refractions from beyond the critical angle, and the time distance variation of this event is almost identical in both directions of shooting, thus indicating an absence of dip.

Using the above velocities, the depth to the Mohorovičić discontinuity is computed to be about 36 km. However, the velocity of 6 km./sec. is not necessarily representative of the whole of the crustal material from the Palæozoic to the Mohorovičić discontinuity, and one would be justified in assigning a somewhat greater velocity than this in the depth calculation and thereby derive a greater depth. Taking a value of 6·3 km./sec. as an average of all published velocities for the crust under North America, the depth to the Mohorovičić discontinuity becomes about 40 km. Furthermore, other distinct events with a velocity of about 7·2 km./sec. have been recorded, and if these are associated with refractions from the lower part of the crust, the depth to the Mohorovičić discontinuity must be increased on this account. A re-computation, including the data from these events and adhering to the velocity of 6·0 km./sec. for the upper layer, yields a total depth to the Mohorovičić discontinuity of 47 km.

The range of depths thus indicated (40–47 km.), suggests that the crust in the western Albertan plains is thicker than the 30–35 km. that has been generally observed in plains areas elsewhere in the world[1]. It appears that crustal thickening that could be expected under the Rocky Mountains extends east of the mountain front at least by 100 km.

The 7·2 km./sec. layer which is inferred to lie at a depth of about 25 km. may be comparable with a 7·0 km./sec. zone observed at the same depth by Hodgson[2] in eastern Canada, and a 7·2–7·4 km./sec. layer noted at 20 km. in California and Nevada by Press[3]. The relatively weak waves refracted from this interface were observed as second events on our records. It is not likely that they could have been identified without multi-trace recording equipment of the type used in seismic prospecting which has been put to good account in the U.S.S.R.[4]. These observations and others recently reported from Europe tend to support the existence of the discontinuity first inferred by Conrad[5] and believed by some seismologists to represent an interface between 'granitic' and 'gabbro' layers within the crust.

It will be interesting to see how this result co-ordinates with the seismic measurements made at the time of the Ripple Rock explosion, since one of the observation stations recording this explosion coincided with one of the shot points in the refraction experiment.

A fuller account of this experiment will be published at a later date.

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Influence of the Semi-Permanent Low-Level Ocean Duct on Centimetre Wave Scatter Propagation beyond the Horizon

Since 1949, the Admiralty Signal and Radar Establishment has conducted a number of short-term investigations on the propagation of centimetric radio waves over sea, at ranges well beyond the radio horizon. Some details of this work have been given recently by Joy[1,2]. It has been shown that, at frequencies of about 10,000 Mc./s., the extra-diffraction signal-levels relative to free space are invariably some 10–15 db. lower than the corresponding levels at 3,000 Mc./s. at all ranges beyond the radio horizon. However, the signal attenuation-rate with distance is very similar at these two frequencies. The observed difference in signal-level is apparently inconsistent with available theories[3,4] of radio wave scattering in the troposphere, and Starkey *et al.*[5] have suggested that it provides support for the alternative theory of layer reflexions from refractive index discontinuities in the lower atmosphere.

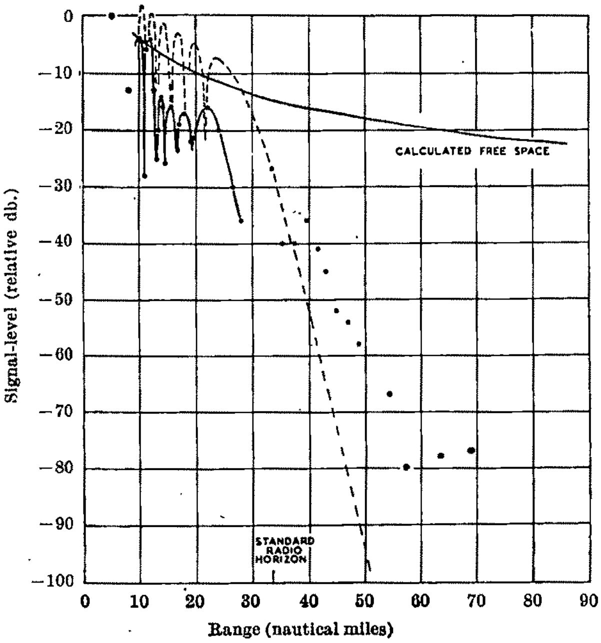

Fig. 1. – – – –, Theoretical interference and diffraction curve for standard atmosphere. Transmitter aerial height, 60 ft.; receiver aerial height, 400 ft.

A significant feature of this Establishment's measurements of signal strength as a function of range at 10,000 Mc./s. over sea paths is that there is a similar degradation in the overall level of the interference pattern relative to the free-space level at ranges approaching that of the radio horizon. Examples of measurements made in the North Sea during the spring of 1956 and in the English Channel in spring 1957 are given by Joy[2]. Examples of further measurements made in the English Channel in the winter of 1957 and spring of 1958 are shown in Figs. 1, 2 and 3.

Fig. 1 shows the interference pattern obtained with a shipborne transmitter aerial at 60 ft. and a land-based receiver aerial at 400 ft. above sea-level. The interference maxima which correspond to the lobes in the vertical coverage diagram at elevations greater than about 0·4° relative to the Earth tangent (ranges less than 12 nautical miles) attain the free-space level while the maxima corresponding to lobes at smaller elevations are depressed by about 12 db. below their theoretical levels.

Figs. 2 and 3 show measurements made using a land-based receiving equipment at 50 ft. and a 10,000 Mc./s. airborne transmitter at 100 ft. and 250 ft. above sea-level respectively. With the transmitter at 100 ft. the theoretical signal-level is approached at elevations exceeding about 1° (ranges less than 1 nautical mile) while for the 250 ft. run

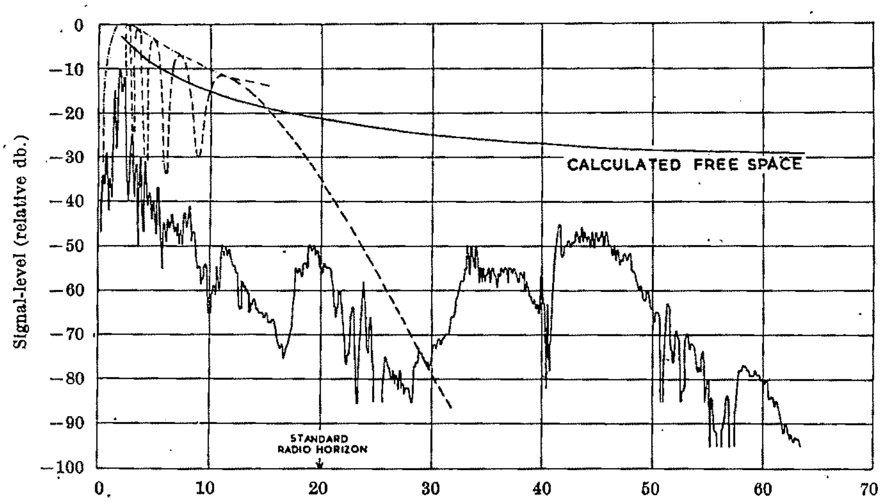

Fig. 2. — — —, Theoretical interference and diffraction curve; —·—·—, theoretical envelope of interference maxima taking account of aerial vertical polar diagrams (all for standard atmosphere). Transmitter aerial height, 100 ft.; receiver aerial height, 50 ft.

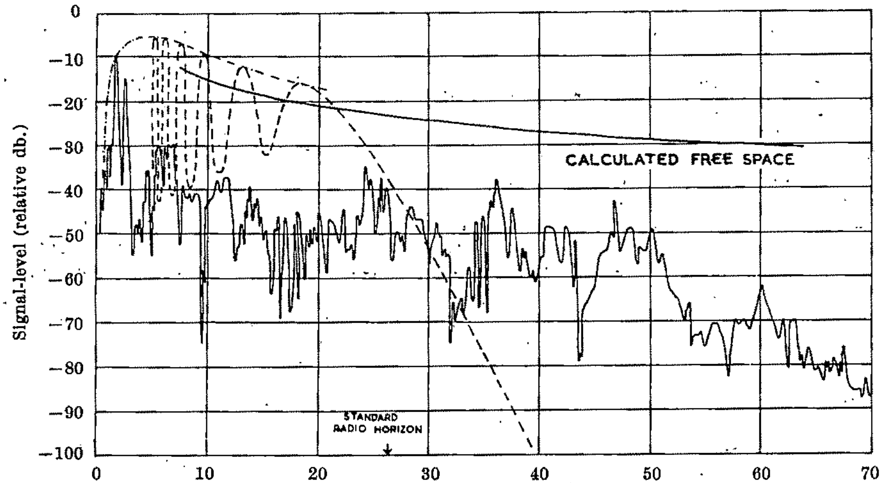

Fig. 3. — — —, Theoretical interference and diffraction curve; —·—·—, theoretical envelope of interference maxima taking account of aerial vertical polar diagrams (all for standard atmosphere). Transmitter aerial height, 250 ft.; receiver aerial height, 50 ft.

the elevation also exceeds about 1° (ranges less than 2 nautical miles).

The distortion of the vertical coverage diagram at low elevations results from the diversion of almost horizontally directed energy by the semi-permanent low-level ocean duct[6]. The energy diverted from the lowest lobes is guided near the surface of the sea well beyond the horizon. With receiving aerials sited relatively high, the surface-guided component of the signal beyond the horizon is not directly observable (Fig. 1). However, with relatively low receiving aerials, the surface-guided energy is clearly apparent (Figs. 2 and 3). Day-to-day variations in the observed signal are experienced as the magnitude and intensity of the duct change.

Since only the low-level lobes contribute to radio wave scattering in the lower troposphere, it follows that any diversion of energy from these lobes will result in correspondingly less power entering the volume common to the transmitter and receiver aerial beams and being scattered in the receiver direction. It follows, therefore, as suggested by Richards[7], that for purposes of applying a scattering theory to the extra-diffraction signal at 10,000 Mc./s. the measured free-space level of the contributing lobes should be used instead of the theoretical value. When this is done there is no longer any marked discrepancy in signal-level at long ranges between 3,000 and 10,000 Mc./s. observations. Since the energy diverted from the lowest lobes at 10,000 Mc./s. reappears as an enhanced surface-guided component it follows that, at ranges well beyond the radio horizon, a high-sited receiving aerial will detect only a degraded scatter signal component, while a low-sited receiving aerial may detect a composite signal consisting of the degraded scatter component plus the surface-guided component. The relative contributions of the incoherent and coherent components in the latter case will vary with short-term variations in the magnitude and intensity of the low-level duct, while the median level of the total signal remains substantially unchanged. Such behaviour has in fact been observed[2].

The normally experienced characteristics of the low-level duct do not permit regular support of a surface-guided component over sea at 3,000 Mc./s. In fact, the extra-diffraction signal fields observed over the sea are in good agreement with the theoretical predictions of scatter theory. The present work makes it clear that the scatter mechanism itself is equally effective at 10,000 Mc./s., but that additional factors are involved in propagation over the sea beyond the horizon which may limit its effective exploitation.

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Determination of Traces of Oxygen in Sodium Metal by Infra-red Spectrophotometry

THE principal methods for the determination of traces of oxygen in sodium metal are based on the titration of sodium monoxide after the metal has been amalgamated and the oxide filtered off[1,2]; distilled in vacuum[3,4]; or allowed to react with an alkyl halide[5]. A 2 gm. sample of sodium metal containing 50 p.p.m. oxygen contains 1·25 × 10^{-5} equivalents of sodium monoxide. In the alkyl halide method, the presence of a 7 × 10^3 fold quantity of sodium bromide introduces difficulties in the determination of sodium monoxide by conventional volumetric methods. Elsewhere this difficulty has been discussed and a solution suggested[6]. The amalgam and distillation methods also suffer from some disadvantages associated with quantitative separation and subsequent estimation of the oxide.

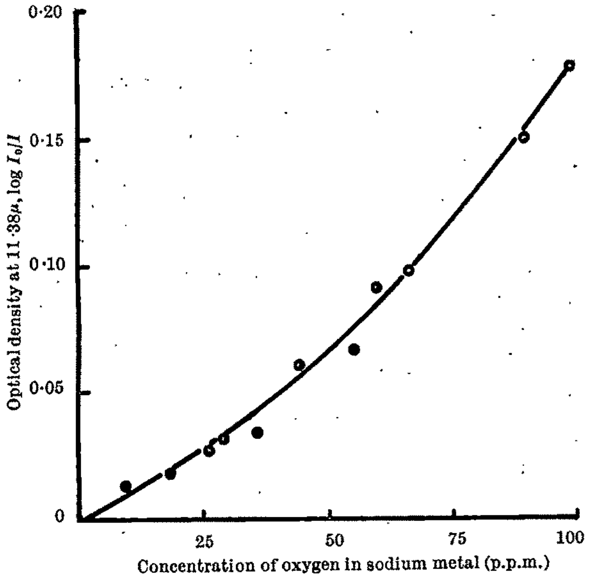

Fig. 1. Oxygen content of sodium metal by infra-red spectrophotometry

The use of an infra-red pressed-disk technique[7] with the alkyl halide method obviates difficulties associated with determinations of sodium monoxide in the range 5–100 p.p.m. in sodium metal. Following the reaction of the sodium metal with the alkyl bromide[5], the reaction mixture is dissolved in water and the unchanged oxide (now hydroxide) is converted into sodium bicarbonate by passing in excess carbon dioxide. The solution is then freeze-dried and the resultant powder heated at 400° C. for 2 hr. 1,500 mgm. of the sodium bromide–sodium carbonate mixture is then compressed to a clear disk by the usual technique[7]. Infra-red spectrophotometric analysis, using a Perkin Elmer model 21 infra-red spectrophotometer, shows absorption bands at 4·00, 6·93, 11·38 and 14·19μ. The absorbance at 11·38μ due to sodium carbonate is not subject to any interference, and although Lambert's law is not obeyed, from a standard curve (Fig. 1) the oxygen concentration in the original metal can be estimated with an accuracy of approximately 10 p.p.m. by weight.

The infra-red procedure also opens the way for the simultaneous determination of other impurities in sodium metal provided that they may be converted quantitatively to compounds with absorption bands in the infra-red region. Full details of the above method will be reported elsewhere.

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A New Configuration of Deoxyribonucleic Acid

STRUCTURES for deoxyribonucleic acid in the *A* and *B* configurations have been described[1]. They are compatible with X-ray diffraction data and embody the base-pairing hypothesis suggested by Watson and Crick[2]. The results we describe here strengthen our belief that no alternative stereochemical hypotheses could be used to build models in agreement with the data.

We have observed a reversible transition between the *B* X-ray diffraction pattern of the lithium salt of deoxyribonucleic acid and a similar but distinct pattern we call *C* (Fig. 1). The transition from *B* to *C* is induced by lowering the relative humidity from 66 to 44 per cent. By slight alteration of the *B* model we have arrived at a model for *C* and accounted for the main differences between *B* and *C* diffraction patterns. The base pairs were moved by about 2 A. away from the helix axis, and tilted by about 5°; the pitch of the helix was altered so that there were 9·3 instead of 10 base pairs per turn.

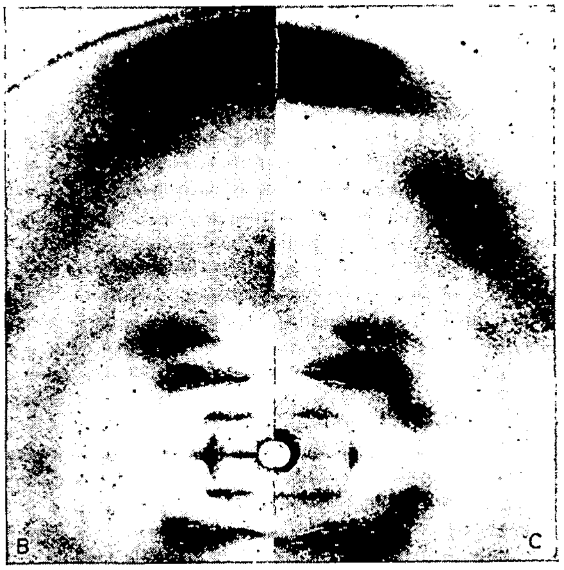

Fig. 1. Diffraction pattern of lithium salt of deoxyribonucleic acid in the *B* (left) and *C* (right) configuration

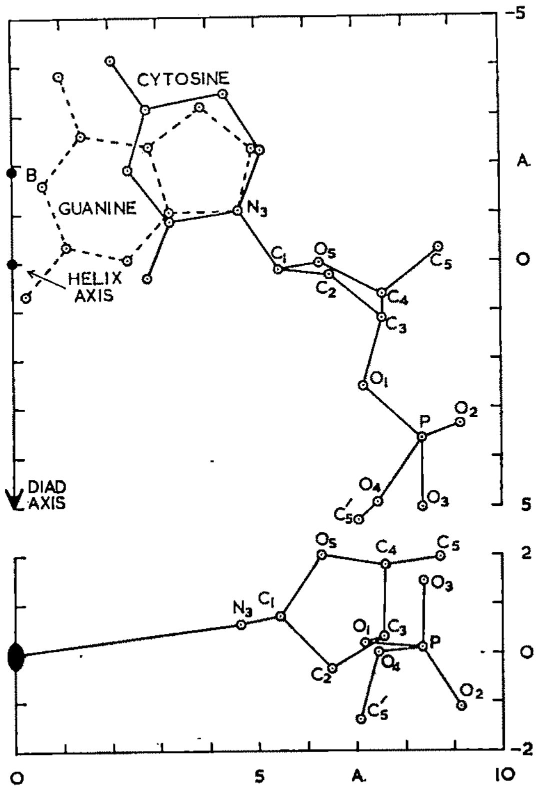

Fig. 2. A preliminary model of the *C* configuration of deoxyribonucleic acid showing approximate projection of a nucleotide on planes perpendicular to the helix and diad axes. *B* is the helix axis in the *B* configuration

In building a molecular model of deoxyribonucleic acid, there is considerable stereochemical freedom in arranging the components and there is, therefore, a small possibility that for any single configuration the agreement between observed and calculated diffraction might be fortuitous. This possibility now seems much smaller, because of our ability to follow the transition between two closely related configurations.

A full account of this work and that on the *B* configuration is being prepared. The work was greatly aided by computer time made available by I.B.M. United Kingdom, Ltd., and I.B.M. World Trade Corporation.

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A Three-stranded Polyribonucleotide Structure

THE synthetic polymers, polyadenylic acid (*A*) and polyuridylic acid (*U*) interact strongly when mixed together in aqueous solution. Evidence for interaction on mixing comes from many observations, including increases in viscosity, sedimentation coefficient and molecular weight and decrease in ultra-violet absorption[1]. The last phenomenon, referred to as a hypochromic effect, is observed in the reverse fashion for deoxyribonucleic acid (P. Doty, private communication), that is, on thermal disruption of the double chain helical molecule in solution there is a substantial increase (about 30 per cent) in the optical density. This parallel behaviour of deoxyribonucleic acid and the chemically related synthetic complex suggests that their structures may be comparable. Added weight to this view is given by X-ray diffraction pictures[2] which show remarkable similarities between naturally occurring deoxyribonucleic acid and a synthetic fibre of polyadenylic acid/polyuridylic acid (*AU*) drawn from a solution containing equimolar portions of polyadenylic and polyuridylic acids. These facts have led Rich[3] to propose that the hydrogen bonding in the polyadenylic acid/polyuridylic acid complex is of the same type as that observed between adenine and thymine in deoxyribonucleic acid.

When the polyadenylic acid/polyuridylic acid complex is mixed in aqueous solution with varying proportions of polyuridylic acid, a maximum drop in the optical density is observed (under appropriate chemical conditions) when the two compounds are present in equimolar amounts[3]. Rich has suggested that this is due to the formation of a three-chain structure, containing one chain of polyadenylic acid and two of polyuridylic acid, and designated *AUU*. Furthermore it has been proposed that the original complex maintains its deoxyribonucleic acid-like structure and that the second chain of polyuridylic acid winds around the first two so as to form a triple helix. In such a structure the only way in which the second polyuridylic acid chain could form two strong hydrogen bonds with the complex is by hydrogen bonding from its O$_6$ and N$_1$ to the adenine N$_{10}$ and N$_1$ respectively. Disregarding the details of Rich's proposal for the moment, it is difficult to explain the spectrophotometric data other than by some sort of three-chain structure; confidence in this type of structure is increased by the observation[4] of a similar hypochromic phenomenon in a different system of polynucleotides containing a 1 : 2 mixture of polyadenylic and polyinosinic acids (*AII*). Unfortunately X-ray diffraction pictures of these three-stranded complexes are not available and, consequently, it is difficult to evaluate molecular models. Aside from purely stereochemical considerations, however, there is new chemical evidence that may be important in judging possible three-chain structures, and I wish to propose a new structure of *AUU* to which I have been led by chemistry rather than by X-ray diffraction.

The chemical evidence on which this new structure is based relates to Rich's observation[3] that the divalent cation, Mg^{++} or Mn^{++}, not only accelerates the reaction $AU + U \rightarrow AUU$ but that it also complexes to the extent of one or two ions per three nucleotides. The problem of binding to nucleic acid by magnesium ions has been studied and reported elsewhere[5,6], and the conclusion was reached that under appropriate conditions the ions[6] will react strongly with deoxyribonucleic acid at sites on the purines which contain configurations favourable for chelation. In particular, adenine in nucleic acid can chelate magnesium ions between the N$_7$ and N$_{10}$ positions of the purine, ring, but only when the plane containing the N$_{10}$ amino-group is turned out of the plane of the purine, because of the steric interference to chelation offered by the amino hydrogens. (It is possible that the amino hydrogens prefer to remain in the plane of the adenine because of the partial double bond character of the C_6—N_{10} bond. In adenine hydrochloride the C_6—N_{10} bond has a length[7] of 1·27 A., corresponding to more than 50 per cent double-bond character. Unfortunately, adenine is not directly comparable with its hydrochloride, since the formation of a resonant hybrid with a C_6—N_{10} double bond involves a separation of charge in the former. Thus one would expect the C_6—N_{10} to have more double-bond character in the hydrochloride. It seems clear that there will be some shortening of the C_6—N_{10} in adenine over the single bond-length, but in view of our ignorance as to its exact amount it is most difficult to say how much stabilization energy will result from this partial double-bond character.) Applying this information to the *AUU* system we see that here there is one purine per three nucleotides and therefore one site per three nucleotides for strongly binding the magnesium ion. The binding of magnesium ions by adenine in *AUU* necessitates the destruction of one of the original hydrogen bonds between the polyadenylic acid/polyuridylic acid double helix because of the required rotation of the N_{10} amino-group. Moreover, it will not be possible to make the hydrogen bonds between the second polyuridylic acid chain and the adenine suggested by Rich because the appropriate binding site on adenine is already occupied by the magnesium ion.

These considerations have led to the investigation of possible alternative structures for *AUU*, which have two strong hydrogen bonds per nucleotide and, furthermore, can accommodate the magnesium ion in the chelating position on adenine. In so doing it has been found that there is only one way of combining the three nucleotides which is sterically feasible. The scheme of hydrogen bonding involves a complicated system of tilts of the planes of the bases and is shown in projection in Fig. 1 for a nucleotide triplet. The hydrogen bond distances, N—H . . . *X*, are given in the figure and in all cases the deviation of N—H . . . *X* from linearity is less than 20°.

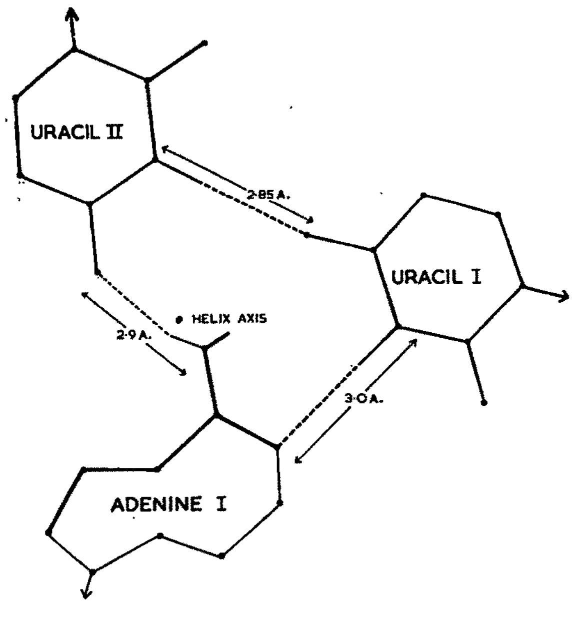

Fig. 1. Base pairing in three-stranded structure. The plane of adenine I is tilted about 44° relative to uracil I and about 37° relative to uracil II

Based on this system of nucleotide hydrogen bonding, a three-chain right-handed helical structure has been built. This model has a unit translation along the helical axis of 4·2 A. and a twist of 36° per triplet to give an exact repeat every thirty nucleotide residues or every ten residues along one chain. The sequence of atoms in the phosphate sugar backbone, which has an average diameter of 19 A., runs in the same direction in all three chains. Adenine I and uracil I (see Fig. 1) are related by a diad axis and as a result the backbone in the two polyuridylic acid chains runs in the same sense relative to the base groups as it does in deoxyribonucleic acid ; but the sense in the polyadenylic acid chain is opposite to that in deoxyribonucleic acid. The planes of the two uracil bases are tilted only a few degrees from the perpendicular to the helix axis, whereas the plane of the adenine is tilted about 40°. The bond distances have been determined to an accuracy of ± 0·15 A. and the bond angles are the same within ± 3° as those in the deoxyribonucleic acid *B* structure[8]. The OH on the C_2 of the ribose has no short contacts in this model except those inherent in the ribose ring. The shortest contact (2·9 A.) observed is that between the ring oxygen of the sugar and the C_4 position on the uracils. However, this could probably be increased by further adjustment. Since so few short van der Waals contacts exist it would appear that a structure of this type is possible ; but it should be emphasized that the dimensions of this model are arbitrary except for the specification of the hydrogen bonding between the nucleotides.

Although the *AII* polymer (mentioned earlier as showing the same hypochromic behaviour as *AUU*) has not been closely examined with models, the same type of hydrogen bonding appears to be possible.

It is interesting that the three-stranded structure for *AUU* proposed here involves molecular rearrangement in the original polyadenylic acid/polyuridylic acid complex prior to the attachment of a second chain of polyuridylic acid. The fact that the *AUU* complex does not form instantaneously in solution from a mixture of polyadenylic acid/polyuridylic acid +polyuridylic acid even under the most favourable conditions[3] must be due to the relatively high energy of the activated complex for its formation. The activated complex most likely involves a strained hydrogen bond between the adenine N_{10} and the uracil O_6 which is on the verge of breaking. It is easy to see that magnesium ions could lower the energy of the activated complex through the formation of a chelate with adenine. This lowering of the activation energy by magnesium ions would account for the fact that the *AUU* complex, although stable in media of high ionic strength lacking divalent cations, nevertheless forms much more rapidly in their presence.

The problem of deoxyribonucleic acid acting as a template for ribonucleic acid formation may be related to the structure of three-chain complexes of the type discussed here, and a specific coding mechanism, involving a three-chain complex as the template mechanism for making nucleic acids, has been proposed[9].

I would like to thank my colleagues at this laboratory for the use of molecular models and for advice and criticism, and also Prof. P. Doty for discussions on the solution chemistry of polynucleotides.

Note added in proof. X-ray pictures, on material containing a 1 : 2 molar ratio of polyadenylic and polyuridylic acids obtained in this laboratory on material given by R. F. Beers and R. F. Steiner, suggest modifications in the model described here. The X-ray pictures suggest that the unit translation along the helical axis be changed from 4·2 A. to 3·86 A. and the twist of 36° per triplet be changed to about 41°. In view of these results and the desirability of obtaining van der Waals contacts between the planes of the base groups, it now seems more reasonable to tilt both adenine I and uracil II about equal amounts (20°) and in the direction of the pitch of the helix. These preliminary results from X-ray diffraction necessitate more detailed consideration which will be presented elsewhere. However, it does not appear that there is any inconsistency with the chemical arguments presented here concerning the hydrogen bonding.

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Vibrational Frequency associated with the Boron–Nitrogen Dative Bond in Amine Boranes

RESEARCH in the chemistry of boron has been extremely active in the past few years and its Lewis acid-base complexes have been of particular interest. Although the boron–nitrogen dative bond is one of the most stable of such bonds to boron and occurs in a number of important boron compounds, the vibrational stretching frequency of this bond in the rather few cases studied has been assigned an unexpectedly high value. For example, in complexes of boron trifluoride with ammonia[1] and nitrogen heterocycles[2], frequencies lying in the range between 980 cm.$^{-1}$ and 1,120 cm.$^{-1}$ have been assigned to this motion, in the complex of boron trimethyl with ammonia, a value of 1,105 cm.$^{-1}$ has been selected[3], and in the complex of borane (BH_3) with nitrogen trimethyl ($N(CH_3)_3$) a value of about 1,250 cm.$^{-1}$ has been given[4]. By way of comparison, frequencies assigned to the covalent carbon–carbon bond in halogenated ethane derivatives, where the masses involved are comparable, range from about 820 cm.$^{-1}$ to 1,075 cm.$^{-1}$. It is, of course, not always a proper comparison merely to look at the magnitude of frequencies in complete disregard of other factors. Nevertheless, chemical data in this case would seem to indicate a lower range for the stretching frequency of the boron–nitrogen dative bond.

We have just completed a Raman spectroscopic study of the 1 : 1 complexes of borane with ammonia and the three methyl amines, including several isotopic derivatives. The preparation of ammonia borane has been described recently[5] and the mono- and di-methylamine derivatives were prepared in similar fashion. The preparation of the trimethyl amine compound is well known. Spectra were obtained in solution in dimethyl ether or liquid ammonia at −40° C. The boron–nitrogen stretching frequency has been identified unambiguously as a well-polarized band of medium intensity at 785 cm.$^{-1}$ in ammonia borane ($H_3N : BH_3$). Confirmation of the assignment is found in the results from the isotopic derivatives. As a first approximation, the NH_3 and BH_3 groups may be considered rigid and the ratio of the boron–nitrogen frequencies of two isotopic molecules should then be determined by the reduced masses of the pseudo-diatomic molecules. The appropriate mass ratios based on the hydrogen compound are compared in Table 1 with the frequency ratios observed. In none of the four cases is the deviation greater than about 2 per cent. The simple boron–nitrogen stretching-force constant calculated from the hydrogen compound datum to this approximation is 2·79 × 10^5 dynes/cm.

Table 1. COMPARISON OF THE BORON–NITROGEN STRETCHING FREQUENCY IN ISOTOPIC DERIVATIVES OF AMMONIA BORANE

Compound	ν (B–N)	ν^*/ν	$\sqrt{\mu/\mu^*}$
	(cm.$^{-1}$)		
$H_3N : BH_3$	785	—	—
$H_3N : BD_3$	737	0·94	0·95
$D_3N : BH_3$	754	0·96	0·97
$D_3N : BD_3$	708	0·90	0·91
$D_3N : B^{10}D_3$	713	0·91	0·93

In the case of the methyl amine derivatives, the band in question appeared with approximately the same intensity and depolarization characteristics but with decreasing frequency as the number of methyl groups on the nitrogen increased (Fig. 1). Examination of the trimethylamine complex prepared using boron-10 in 96 per cent enrichment showed the assigned band at 667 cm.$^{-1}$ in the normal compound shifted to 676 cm.$^{-1}$ in the isotopic, whereas the previously assigned[4] band near 1,250 cm.$^{-1}$ was found to shift only 2 cm.$^{-1}$, an amount nearly within the precision of the measurements. The earlier assignment thus appears doubtful, particularly since the 1,250 cm.$^{-1}$ band is weak in the Raman effect.

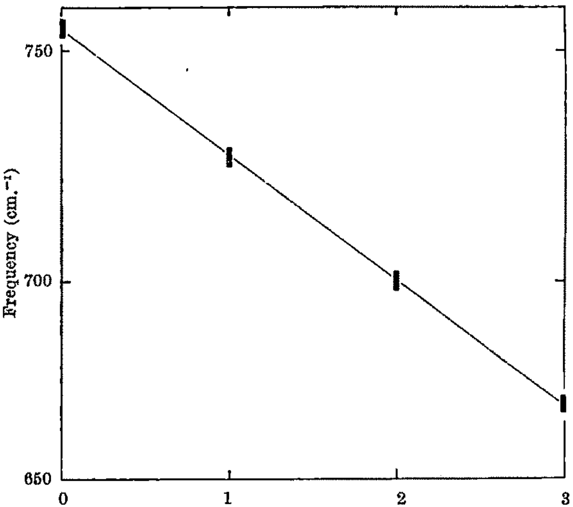

Fig. 1. The vibrational stretching frequency associated with the boron–nitrogen dative bond in some amine boranes

The spectral range within which the boron–nitrogen frequency was found in the present investigation is in good agreement with the frequencies available for other dative bonds to boron in complexes of borane with ligands such as carbon monoxide, phosphorus trifluoride and dimethyl ether.

A more complete presentation of the results will be published elsewhere. This research was supported by the Aeronautical Research Laboratory, Wright Air Development Center, Air Research and Development Command, U.S. Air Force, Wright-Patterson Air Force Base, Ohio.

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Molecular Structure of *cyclo*-Octatetraene

AN investigation of the nuclear magnetic resonance absorption spectrum of solid *cyclo*-octatetraene has been made with the object of obtaining information about its molecular structure. Previous determinations of the molecular structure of *cyclo*-octatetraene have used the techniques of infra-red and Raman spectroscopy, and of electron diffraction. The results have been explained in terms of three different molecular models: (1) the 'crown' (D_4) structure with alternate double and single bonds[1]; (2) the 'crown' (D_{4d}) structure with equivalent bonds[2]; (3) the 'tub' (D_{2d}) structure with double and single bonds[3]. Subsequent investigations have supported one or other of these models, but with no real agreement as to which is the most likely structure. Theoretical predictions of the vibrational spectra and diffraction patterns of these three molecular configurations show little difference.

In certain cases, information obtained from a study of the nuclear magnetic resonance absorption spectrum can give valuable information distinguishing between various proposed molecular models. Accordingly the second moment of the proton resonance absorption line was measured at a temperature close to the melting point. The mean value obtained was 7·9 ± 0·2 gauss^2. This has to be compared with the theoretical values calculated for each of the three different configurations. The expected second moment was also calculated for the simple planar model with equivalent bonds, although the above results showed that this was a very unlikely possibility. The results are shown in Table 1.

The C—C and C=C bonds were taken as 1·54 A. and 1·34 A. respectively. The equivalent C—C bond was taken as 1·42 A., being 2 per cent greater than the corresponding bond-length in benzene, as suggested by Bastiansen *et al.*[2]. The D_4 and D_{2d} structures were assumed to have angles of 125° between the carbon bonds, the D_{4d} structure 120° between these bonds and the plane molecule, being in the form of a regular octagon, angles of 135° between the carbon bonds. The C—H bond-length was taken as 1·07 A. for the D_4 and D_{2d} structures and as 1·08 A. for the D_{4d} and planar structures. The intermolecular contribution to the second moment (due to interactions between protons in different molecules) was calculated on the basis of the orthorhombic crystal structure found by Kaufman, Fankuchen and Mark[4], with reasonable assumptions regarding the orientation of the molecules in the cell.

Table 1

Molecular structure	Second moment of absorption lineshape in gauss^2		
	Intramolecular	Intermolecular	Total
D_4	2·38	7·75	10·13
D_{4d}	1·99	7·05	9·04
D_{2d}	2·99	5·00	7·99
Plane	5·75	5·47	11·22

Comparison of the experimental and theoretical values for the second moment indicates that the 'tub' D_{2d} structure is the most probable one for *cyclo*-octatetraene. The D_{4d} structure gives a second moment which is more than 1 gauss^2 too large, but it must be mentioned that the intermolecular contribution to this second moment amounts to 78 per cent of the total. This is the least accurate part of the calculation because of the assumption made regarding the orientation of the molecule in the unit cell. There is, therefore, some uncertainty in the value 7·05 gauss^2 for the intermolecular part of the second moment, but it is not thought to be so large as to reduce this value by as much as 1 gauss^2.

The D_{2d} structure for *cyclo*-octatetraene has recently been confirmed using highly refined electron diffraction techniques by Bastiansen, Hedberg and Hedberg[5], reported after the completion of the present work.

The *cyclo*-octatetraene was kindly supplied by the British Oxygen Research and Development, Limited.

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Use of Molecular Sieves in Gas Chromatography for the Determination of the Normal Paraffins in Petroleum Fractions

THE use of Linde molecular sieve 5*A* in conjunction with gas chromatography[1–3] offers considerable promise as a means of determining *n*-paraffins in hydrocarbon mixtures. Recently, Brenner and Coates[4] reported the application of this technique to the identification of *n*-paraffins in the C_3 to C_{11} (gasoline) range. We have successfully used it in a higher molecular weight range, namely, for the determination of the *n*-paraffin content and distribution in kerosines and gas oils. Since this may also be of general interest our method will be outlined here.

The saturated fraction of the kerosine or gas oil was separated by liquid–solid chromatography and a portion run through a 2-metre gas chromatographic column packed with 30–60 mesh 'Sil-o-cel' firebrick coated with 26 per cent by weight of silicone grease *E* 301 (Imperial Chemical Industries). The type of chromatogram obtained for a kerosine fraction at a column temperature of 164° C. is shown in Fig. 1*a*. The normal paraffin peaks have been shaded to show how they are superimposed upon and only partially separated from the other saturated hydrocarbons. A pre-column of 11 cm. length packed with 30–60 mesh Linde molecular sieve 5*A* coated with 1·6 per cent by weight of squalane, to prevent tailing effects, was now attached to the main column and maintained at 150° C. A further similar portion of the saturated fraction of the kerosine was run through this dual column and a second chromatogram obtained (Fig. 1*b*) free from the normal paraffins which were retained by the molecular sieve. The difference in area between the two chromatograms was a measure of the normal paraffin content, and the amount of each individual normal paraffin was similarly obtained from the difference in peak area at the respective normal paraffin elution times on the two chromatograms when using hydrogen as the carrier gas with a thermal conductivity detector. Typical results obtained are shown in Table 1 and the total normal paraffin contents are compared with those obtained by a liquid phase separation with molecular sieves.

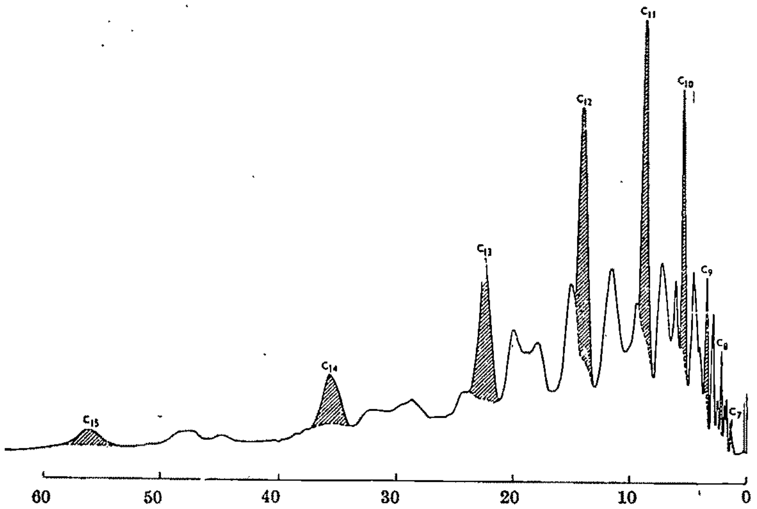

Fig. 1*a*. Chromatogram of a kerosine saturated fraction showing the *n*-paraffin peaks. Sample size, 13 µl.; column, 200 cm. × 6 mm. internal diameter, 26 per cent silicone grease *E*301 on 30–60 mesh 'Sil-o-cel' furnace brick; column temperature, 164° C.; katharometer temperature, 170° C.; carrier gas, hydrogen; outlet pressure, atmospheric

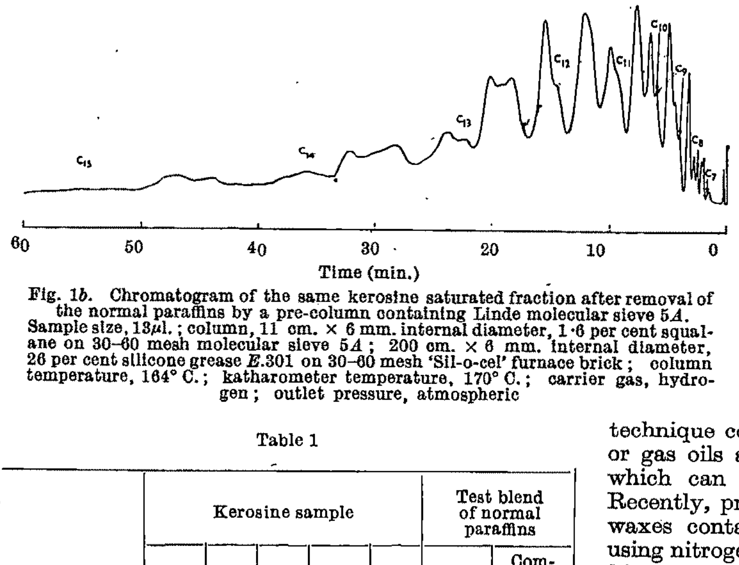

Fig. 1*b*. Chromatogram of the same kerosine saturated fraction after removal of the normal paraffins by a pre-column containing Linde molecular sieve 5*A*. Sample size, 13µl.; column, 11 cm. × 6 mm. internal diameter, 1·6 per cent squalane on 30–60 mesh molecular sieve 5*A*; 200 cm. × 6 mm. internal diameter, 26 per cent silicone grease *E*.301 on 30–60 mesh 'Sil-o-cel' furnace brick; column temperature, 164° C.; katharometer temperature, 170° C.; carrier gas, hydrogen; outlet pressure, atmospheric

Table 1

Percentage by volume	Kerosine sample					Test blend of normal paraffins	
	1	2	3	4	5	Actual composition	Composition from gas-liquid chromatography
Total *n*-paraffin by molecular sieve (liquid phase)	22	27	26	11	9		
Total *n*-paraffin by molecular sieve (gas phase)	23	31	26	12	8		
Individual *n*-paraffins							
C_7	Trace	—	—	Trace	—	—	—
C_8	1·0	0·6	0·2	0·1	0·8	—	—
C_9	4·9	3·6	0·6	0·9	1·8	3·1	3·4
C_{10}	5·3	9·2	1·8	2·3	1·7	7·7	8·3
C_{11}	4·8	8·4	6·5	2·4	1·5	22·6	22·5
C_{12}	3·9	6·2	5·5	2·2	1·1	29·8	29·7
C_{13}	1·9	2·3	4·8	1·9	0·7	22·2	22·5
C_{14}	0·9	0·5	4·0	1·3	0·4	14·6	13·6
C_{15}	0·3	0·2	1·9	0·6	—	—	—
C_{16}	—	—	0·7	0·3	—	—	—

The molecular sieve pre-columns have retained their capacity to adsorb the normal paraffins from at least 30 kerosine samples representing approximately 85 mgm. of adsorbate. It seems that the same technique could be applied to the original kerosines or gas oils and indeed to any hydrocarbon mixture which can be separated by gas chromatography. Recently, promising results have been obtained with waxes containing normal paraffins as high as C_{40} using nitrogen carrier gas and a 0·6 m. column with a 10 cm. pre-column containing the molecular sieve. As squalane could not be used to reduce tailing at high temperatures it was found that this effect could be eliminated by maintaining the pre-column at a temperature of 320° C. while the main column was operating at temperatures in the range 270–300° C.

I wish to thank the Directors of Shell Research Ltd., for permission to publish this communication, and Miss P. M. Higham and Mr. J. B. Shortall, who have taken part in the work described.

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Swift Combustion of Organic Compounds for Analysis

A NOVEL apparatus has been designed for rapid combustion of organic compounds, including volatile ones, for analysis (Fig. 1). A closed system is used, as by Mikl and Pecht[1], and Schöniger[2 3], while retaining platinum contacts as used by Pregl[4] and the usual method of taking samples.

The apparatus (patent applied for by Loughborough Glass Co., Ltd., Loughborough) consists of a quartz bulb *V*, equipped with a *B*24 joint opposite a combustion U-tube *CT*, the limbs of which are sufficiently close together to allow heating by a single flame. The flask is connected via joint *B*24 to syphon tube *T* in reservoir *R*, which can be closed with stopper *B*19 in a socket extended into a funnel *F*.

To carry out the combustion, the apparatus is flushed with oxygen. A sample between 3 and 7 mgm. is weighed, solids in boats and liquids in capillaries. The sample in its container is placed in a glass tube, one end of which is held against one orifice of tube *CT*, while the container is pushed forward with a glass rod. Capillaries are placed in tube *CT* with the open end forward. Volatile compounds are cooled by placing solid carbon dioxide externally over the sample. In the same way contacts *C* are inserted on both sides of tube *CT*. Reservoir *R* is half-filled with absorption solution, and attached to bulb *V*, a wetted 'Teflon' sleeve *TS* being slipped over the stopper, which is held by springs. Two asbestos sheets, *Asb*, are arranged over combustion tube *CT*. The platinum contacts *C* are then heated by burner *B*. Excess oxygen will escape freely through the absorption solution. When burning volatile compounds, solid carbon dioxide is kept over the sample until the contacts are glowing. Then reservoir *R* is closed with stopper *B*19, and combustion of the compound carefully started using a microburner. The rate of volatilizing can be assessed by the speed of bubbles escaping tube *T*. Combustion is completed by heating the whole length of tube *CT* with a second burner. The apparatus is left to cool, or cooled rapidly using a damp cloth. Funnel *F* is filled with distilled water and stopper *B*19 carefully lifted until the water is sucked in. The contents are shaken. Funnel *F* is filled again with distilled water and this procedure repeated four times. The absorption tube and contacts are removed, rinsed quantitatively, and the contents of the flask transferred to a container according to the analysis required. Many methods described in the literature will be found suitable for the determination of halogens and sulphur in that solution.

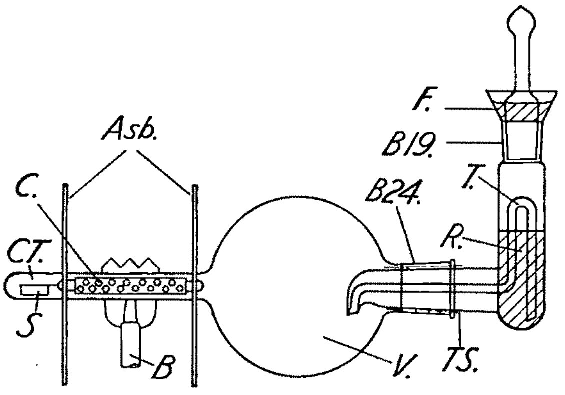

Fig. 1

Table 1

Compound	Sample (mgm.)	Percentage chlorine	
		Calc.	Found
Carbon tetrachloride	3·230	92·19	92·23
	3·600		92·26
	3·662		91·79
	4·072		92·59
Chloroform	3·150	89·10	88·71
	3·857		88·70
	3·022		89·38
	4·070		88·61
Hexachlorobenzene	4·402	74·70	74·64
	4·559		74·88
	4·776		74·46
	5·190		74·57
p-Chlorobenzoic acid	5·870	22·65	22·53
	4·540		22·76
	5·571		22·77
	4·053		22·68

Results obtained by analysis of chlorine, using the combustion procedure described, followed by potentiometrical titration with silver nitrate by Clark's method[5], are given in Table 1. Results for other halogens, sulphur and possibly phosphorus will be published later in detail.

My thanks are due to Miss P. Johnson and Mrs. V. Taylor for most efficient assistance, to Mr. Evans for skilful work in making this apparatus, to Mr. Lambie for encouragement throughout, and to the Directors of Fisons Pest Control, Ltd., for permission to publish this communication.

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Essex.
June 20.

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Some Complex Cyanides of Rhenium

SEVERAL attempts have been made to prepare complex rhenium cyanides, but invariably these have resulted in mixed compounds. For example, in 1932 Turkiewicz[1] obtained $K_3[ReO(CN)_4OH]$, and later Morgan[2] prepared $K_3[ReO(CN)_4]$; Klemm and Frischmuth[3] and Morgan and Davis[4] described the preparation of $K_3[ReO_2(CN)_4]$. A rhenium carbonyl cyanide anion $[Re(CO)_4(CN)_2]^-$ was reported by Hieber and Schuster[5]. The only evidence in the literature for the existence of a true complex rhenium cyanide comes from polarographic studies[6,7].

We report the preparation of the binary complex rhenium octacyanides, potassium octacyanorhenate-V, $K_3Re(CN)_8$, and potassium octacyanorhenate-VI, $K_2Re(CN)_8$. With the exception of the well-known molybdenum and tungsten compounds, these are the only eight-co-ordinate cyanides, so far reported, and the first eight-co-ordinate rhenium compounds.

When potassium hexa-iodorhenate-IV, K_2ReI_6, is added to potassium cyanide in methanol, the octacyanorhenate-V is formed as a brown precipitate. Found: Re, 34·4; K, 21·9; C, 18·6; H_2O, 3·3. Required for $K_3Re(CN)_8 \cdot 1H_2O$: Re, 35·1; K, 22·1; C, 18·1; H_2O, 3·4.

Potassium octacyanorhenate-V dissolves in water to give a stable yellowish-brown solution which yields the free acid when passed through an ion exchange column.

When concentrated nitric acid is added to potassium octacyanorhenate-V solution, a reddish product can be isolated which shows a peak in its infra-red spectrum at 1,875 cm.$^{-1}$, a value which is assigned to the NO stretching frequency. Treatment of potassium octacyanorhenate-V solution with concentrated hydrochloric acid yields a purple solution. A potassium salt cannot be isolated from this solution, but addition of hexamine cobaltic chloride gives an insoluble purple precipitate which is hexammine cobaltic octacyanorhenate-VI, $[\mathrm{Co(NH_3)_6}]_2[\mathrm{Re(CN)_8}]_3$, the cobalt hexammine salt of the $[\mathrm{Re(CN)_8}]^{=}$ ion. Found : Co, 7·8 ; Re, 36·0. Required for $[\mathrm{Co(NH_3)_6}]_2$ $[\mathrm{Re(CN)_8}]_3$: Co, 7·8 ; Re, 36·5.

The infra-red spectrum of potassium octacyanorhenate-V in 'Nujol' mull shows three cyanide-stretching frequencies at 2,140 cm.$^{-1}$, 2,110 cm.$^{-1}$ and 2,050 cm.$^{-1}$, very similar to the infra-red spectra of the molybdenum and tungsten octacyanides[8]. The spectrum also shows a sharp peak at 780 cm.$^{-1}$, which may be either a Re—C stretching mode or a C≡N wagging mode.

Potassium octacyanorhenate-V is diamagnetic. The oxidation from rhenium-IV to rhenium-V during the preparation is of some interest. Considering an octa-co-ordinate cyanide complex for rhenium-IV, of the three *d*-electrons two may enter the non-bonding stable 5*d*-orbital which is unused in σ-bonding ; the third, however, would have to enter a high-energy orbital, most likely one of the anti-bonding σ-orbitals, from which it is readily lost.

The hexammine cobaltic salt of the octacyanorhenate-VI ion is paramagnetic with a magnetic moment of 2·0 Bohr magnetons.

A detailed account of this work will be published elsewhere.

One of us (R. C.) thanks the Atomic Energy Authority for a student maintenance grant and research expenses.

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Moving Acid Boundary (*p*H Gradient) Paper Ionophoresis of Bile Salts

Methods have been devised for the separation of bile acids and their conjugates with glycine or taurine using partition chromatography on columns[1,2] or paper[3,4]. These methods, however, may confuse certain glycine conjugated acids with the unconjugated bile acids containing a greater number of hydroxyl groups[4]. Thus ambiguous separations may result if unconjugated bile acids are also present in the mixture.

Free[5,6] and paper[7] electrophoresis with a stationary *p*H gradient has been used to separate proteins on the basis of differences in their isoelectric points. We have applied ionophoresis with a moving acid front to separate bile salt mixtures utilizing the differences in acid dissociation constants. (The pK_a's of taurocholic, glycocholic and cholic acids are respectively 1·4, 4·4 and 6·4). With this method, using a standard paper ionophoresis apparatus, a bile salt mixture can be separated into three groups : unconjugated bile acids, glycine conjugates and taurine conjugates.

The cathode compartment contains 0·05 *M* acetate buffer, *p*H 4·8 and 0·03 *M* sodium chloride. The anode compartment contains 0·05 *M* monochloroacetate buffer, *p*H 2·7, and 0·03 *M* sodium chloride. Up to 500 μgm. of the bile salt mixture is applied to a strip of Whatman No. 3 paper (6·5 cm. × 46 cm.), 15 cm. from one end. The paper is impregnated with acetate buffer and placed in the ionophoresis apparatus with the point of application nearest the cathode chamber. The separation is carried out for 16 hr. under a potential gradient of 5 V./cm.

Initially at *p*H 4·8, the conjugated bile acids migrate together toward the anode, the weaker unconjugated acids being immobile. As the separation progresses, the simultaneous migration of hydrogen ions from the anode compartment (the advancing acid front) represses the ionization of the glycine conjugates. These are consequently rendered immobile. The taurine conjugates continue to move through the acid front and are found near the anode. The glycine conjugates and the free acids are located near the middle of the paper and origin, respectively. Afterwards each area may be eluted, the substances separated, and identified by appropriate chromatographic procedure.

The presence of buffered salt mixtures in the paper may seriously interfere with the location of the bile acids by the colorimetric reagents commonly employed[8]. A reagent which has been found useful is 3 per cent (w/v) vanillin and 15 per cent (v/v) phosphoric acid in *sec*-butanol.

This method has been used to separate mixtures of pure synthetic conjugated bile acids as well as crude mixtures of natural origin. The presence of unconjugated cholic acid in the latter has been demonstrated.

The application of an effective *p*H gradient during ionophoresis promises to be of much use for the separation of compounds differing in their ionization constants as acids or bases. This method eliminates the necessity of conducting ionophoresis at two or more *p*H's in order to identify, for example, carboxylic acids in the presence of phosphate esters.

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Experimental Chemotherapy of Tumours with Hydrogen Peroxide

R. A. Holman has reported[1] that a high percentage of rats bearing Walker carcinoma 256 were cured after drinking hydrogen peroxide instead of water. These findings were not confirmed by Green and Westrop[2], nor by Ghadially and Wiseman[3] using Walker carcinoma 256 and Sheffield *RD*/3 sarcoma in rats. We have repeated Holman's experiment with some transplantable tumours of mice and rats.

Table 1. Animals and Tumours used in the Experiments

Group	Animals	Sex	Strain	Tumours	No. of animals fed: hydrogen peroxide	No. of animals fed: distilled water
I	Mice	*F*	*Br**	Transplantable solid carcinoma of the breast (G_4)	25	25
II	Mice	*F*	*A*	Transplantable adenocarcinoma of the breast (G_{44})	10	6
III	Mice	*F*	*Br**	Crocker sarcoma	15	15
IV	Mice	*F*	Hybrids	Ehrlich ascites carcinoma	14	14
V	Rats	*F*	Wistar	Guerin carcinoma	8	8
	Rats	*M*	Wistar	Guerin carcinoma	8	8

* Inbred strains from our animal colony.

One group of animals was given commercial hydrogen peroxide (diluted to final concentration of 0·45 per cent in distilled water) to drink; the other received distilled water. Both hydrogen peroxide and distilled water were supplied in dark bottles refilled every day. Both groups of animals received the standard diet used in our animal colony.

In groups I, II, III and V (Table 1), treatment with hydrogen peroxide was started 7, 3, 14 and 19 days respectively after implantation of grafts. In group IV (Ehrlich ascites carcinoma) treatment with hydrogen peroxide was started the day after transplantation.

The rate of growth of the solid tumours was expressed as a mean diameter, measurements of tumours being made two or three times a week, using Schrek's technique[4] as modified in our laboratory. In the case of Ehrlich carcinoma both groups of mice were weighed daily. In all cases the time of survival of the animals was noted.

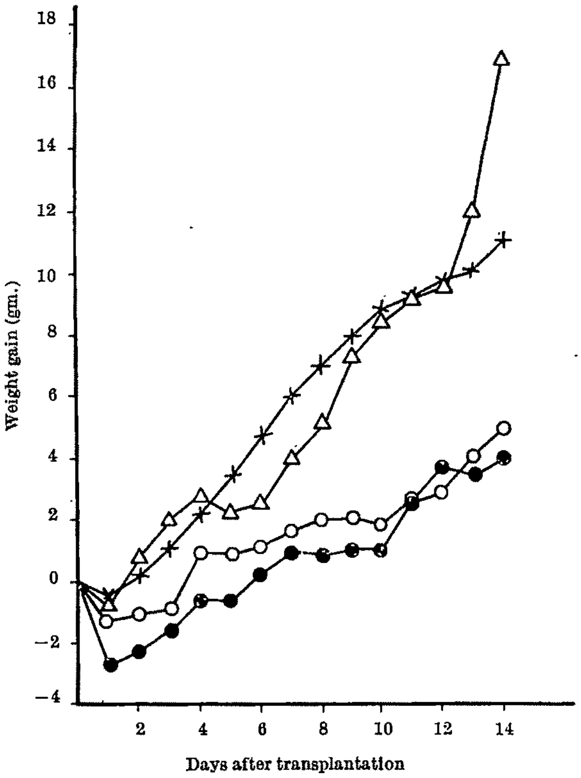

Fig. 2. Ehrlich ascites sarcoma: gain in weight of mice on hydrogen peroxide compared with those on distilled water. Experiments performed on two groups of animals: group (*a*) had an average initial weight about 25 gm., group (*b*) about 18 gm. —●—, (*a*) and —○—, (*b*), hydrogen peroxide-treated; —△—, (*a*), and —×—, (*b*), distilled water-treated

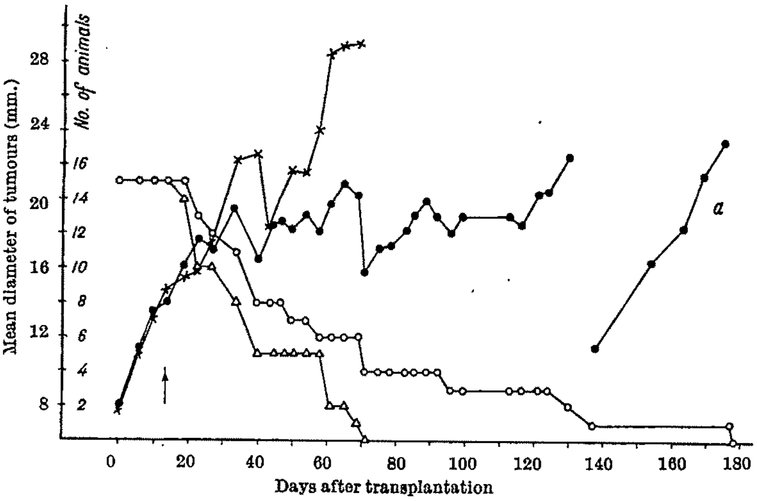

Fig. 1. Crocker sarcoma: survival time of mice receiving hydrogen peroxide (—○—) and distilled water (—△—). Rate of growth of tumours of hydrogen peroxide-treated (—●—) and control (—×—) animals; size of tumours expressed as mean diameter of tumour, averaged from tumours of animals living on a given day. The arrow indicates the start of treatment with hydrogen peroxide. Curve *a*, rate of growth of tumour in the single mouse surviving

No significant effect of hydrogen peroxide on the rate of growth of tumours or on survival-time was observed in groups I, II and V. The results obtained with groups III and IV are illustrated in Figs. 1, 2 and 3.

As can be seen from Fig. 1, the rate of growth of Crocker sarcoma in mice fed on hydrogen peroxide was somewhat slower than in the control group. The regression of tumours in the treated group was not observed; however, the growth of some tumours became stationary. The effect was responsible for the prolongation of survival-time in these animals (Fig. 1). When the 'stationary period' ended, the rate of growth of the tumours of treated animals was almost as great as in control ones. This is well illustrated by the rate of growth of a tumour in the mouse which had the longest survival time (Fig. 1,*a*).

The rate of growth of Ehrlich ascites carcinoma, as expressed by the gain in weight of the animals, was diminished in the group treated with

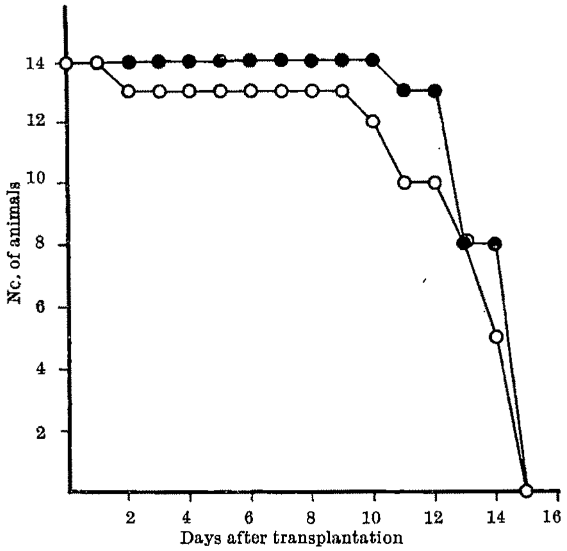

Fig. 3. Ehrlich ascites sarcoma: survival time of hydrogen peroxide-treated (—●—) and control (—○—) mice

hydrogen peroxide (Fig. 2), yet the treatment had no influence on the survival time of these mice (Fig. 3).

From this work it is not possible to assess the activity of hydrogen peroxide *per se* against tumour growth, because of some uncontrolled experimental conditions. In particular, the intake of food and water must be taken into consideration. We noticed that the intake of hydrogen peroxide solution by treated animals was much smaller than the intake of distilled water by control animals. Diminished food intake followed by loss of weight in healthy rats drinking hydrogen peroxide as compared with rats supplied with tap water was observed by Ghadially and Wiseman[3]. It seems very probable that changes in nutritional conditions brought about by drinking hydrogen peroxide (diminished food intake, or direct action of hydrogen peroxide on some essential constituents of ingested food) may be causal factors sometimes mediating an inhibitory effect on certain kinds of tumours.

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Anticholesterol Activity of α-Lipoic Acid

A recent report in *Nature*[1] concerning the 'anticholesterol' properties of α-lipoic acid has prompted communication of similar experiments in which different results were obtained.

In our work two groups of male Dutch belted rabbits (*A* and *B*) were maintained on a diet containing 2 per cent cholesterol and 6 per cent corn oil for two months. A third group (*C*) was kept as a normal control. One of these groups (*B*) also received daily intraperitoneal injections of 1 mgm. of α-lipoic acid, which represented 0·5–1 mgm./kgm. body-weight for the animals used. After eight weeks the animals were killed, the sera assayed chemically for cholesterol[2] and ultracentrifugally for β-lipoproteins[3] and the aortas graded visually (on a 0–4 scale) for atheromata. The results are shown in Table 1.

Table 1. Autopsy Results for Rabbits fed with Cholesterol

Group	No.	Atheromata (average) Arch	Thoracic	Liver weight (gm.)	Gain in weight (gm.)
A	10	2·10	1·25	93	219
B	10	2·50	1·65	90	49
C	5	0·00	0·10	63	449

Table 2. Serum of Rabbits fed with Cholesterol

Group	Average cholesterol (mgm./100 ml.)	Average lipoproteins (mgm./100 ml.) *Sf* 0–11	12–20	21–35	35–100	100–400
A	1,893	220	517	839	997	663
B	1,853	263	731	1,015	782	443
C	175	146	75	43	30	25

The most obvious source of discrepancy is the fact that Angelucci and Mascitelli-Coreandoli[1] administered considerably more α-lipoic acid than we did. In the absence of weights of the animals, it cannot be said if their rabbits showed even less weight gain than ours did. It is also worth noting that whereas their lipoic-acid group showed 20 per cent of the serum cholesterol-levels of the cholesterol-fed controls, they showed 66 per cent of the aorta cholesterol. In our work there was increased atherosclerosis in the lipoic acid group.

These results, indicating one of the lower limits at which no effect of α-lipoic is discernible, may serve as a guide in defining dosages, and may stimulate further work.

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The discrepancy between our results and those of Kritchevsky and Moyer could be explained as follows:

(*a*) In comparison with the dosages used by Kritchevsky and Moyer, our rabbits were given a smaller total amount of cholesterol and a greater total amount of α-lipoic acid, with a ratio between cholesterol and α-lipoic acid comparatively in favour of the latter in unit time.

(*b*) That there is a critical value in the α-lipoic acid dosage for the 'anticholesterol properties' can be argued from the fact that in humans with high serum cholesterol-levels, chronic treatment with α-lipoic acid 25 mgm. twice a day did not change the serum cholesterol-levels, whereas 50 mgm. once a day gave a moderate decrease in the serum cholesterol levels (Consolo *et al.*, *Boll. Soc. Ital. Biol. Sper.*, 32, 1325; 1957).

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Existence and Significance of a Physiological Anticoagulating System

When moderate doses of tissue thromboplastin are injected into the jugular vein of rats the circulating blood loses its clotting properties, with the result that no intravascular thrombi are, as a rule, produced. This effect of thromboplastin depends upon its capacity for inducing the formation of thrombin in blood from the plasma prothrombin. In most cases intravenous administration of moderate doses of thrombin to healthy animals does not cause thrombosis, for the clotting mechanism becomes disordered almost immediately after the injections. At the same time the thromboplastic activity of blood shows a sharp decrease, while fibrinogen capable of reacting with thrombin disappears and heparin-like substances appear in the blood. This protective reaction, maintaining the blood in a fluid state in the vascular bed when thrombin arises in it, is brought about by the physiological anticoagulating system. Experiments have shown that in narcotic sleep resulting from inhalation of sulphuric ether, as well as from anæsthesia produced by an intramuscular injection of novocaine on both sides of the spinal column, this anticoagulating system ceases to function. It is this effect that accounts for the fact that coagulation of circulating blood and death from thrombosis have been found to occur in anæsthetized test animals (as opposed to controls in a normal physiological condition) after an intravenous administration of certain doses of thrombin (Table 1).

It thus appears possible that there may exist certain receptors in the blood vessels which react to the presence of thrombin and actuate the neuro-humoral mechanism, preventing coagulation of the blood circulating in the vessels. There is no doubt that pathological changes in the vessel walls as well as impairment of circulation may lead to the formation of thrombin in the vascular bed. Whereas with an anticoagulating system functioning normally, the coagulation of the circulating blood is to a certain extent avoided, in any disturbance of that system the appearance of thrombin in the circulating blood, whatever its cause may be, can give rise to the formation of clots.

It is probable that the anticoagulating system partly loses its function as a result of changes in the body with age and of toxic effects occurring in case of some infectious diseases, as well as in narcosis or anæsthesia (post-operative thrombosis). The latter fact is proved experimentally. It is possible that in the normal physiology of blood a restricted formation of thrombin in the vascular bed is constantly taking place, but the blood does not clot owing to the action of the physiological anticoagulating system.

In cases of disturbance of the anticoagulating system, even with decreased prothrombin content in the blood and its slower conversion to thrombin, the possibility of the formation of thrombin still remains, a fact which does not exclude the conversion of fibrinogen to fibrin in the vascular bed.

On the basis of this hypothesis, the problem of thromboses should be approached not from the point of view of an excess of coagulating components in the circulating blood or the pathology of the vessel wall but through an analysis of the physiological state of the anticoagulating system present outside the vascular bed.

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Table 1. Inhibition of the Anticoagulating System under the Influence of Ether or Novocaine Anæsthesia

No. of animals	Activity of thrombin (sec.)*	Dose of intravenous thrombin (ml.)	Experimental conditions	No. of animals surviving	No. of animals dead from thrombosis
30	6	0·5	Animals anæsthetized with ether after 15 min. sleep	5	25
30	6	0·5	Control animals in normal physiological state	26	4
30	6	1·0	Control animals anæsthetized with ether after 15 min. sleep. Thrombin fully inactivated by heating for 6 min at 57° C.	30	0
30	6	0·5	Animals given intramuscular injections of novocaine along spinal column	11	19
30	6	0·5	Control animals in normal physiological state	26	4
30	6	0·5	Control animals given intramuscular injections of novocaine along spinal column. Thrombin fully inactivated by heating for 6 min. at 57° C.	27	3

* Thrombin solution clotted an equal volume of oxalated blood in 6 sec. at 37° C.

Carbohydrate Metabolism of Cock Spermatozoa

Glycolysis in spermatozoa of mammalian species has been much studied. These investigations, extensively reviewed by Mann[1], have demonstrated that mammalian spermatozoa utilize fructose, glucose and mannose; anaerobically, they degrade these sugars to lactic acid, deriving from this process the energy necessary for motility.

Winberg[2] demonstrated that cock spermatozoa produce lactic acid by aerobic glycolysis of glucose, fructose or mannose, and that these sugars (and also maltose to a slight extent) support their respiration, but to my knowledge glycolysis in avian spermatozoa has not been further studied systematically. This communication reports the results of an investigation on the carbohydrate metabolism of spermatozoa of the domestic cock (*Gallus domesticus*).

Semen collected from Rhode Island Red cocks by the abdominal massage method of Burrows and Quinn[3] was diluted, within 20 min. of collection, with the pre-warmed appropriate medium, and then, after removing an aliquot for initial analysis, was incubated in a water-bath at 40° C. The incubation was carried out in two ways: (1) in stoppered, 7–75-mm. test tubes containing 1–2 ml. of the mixture, which were left undisturbed in the bath, thus providing semi-anaerobic conditions, and (2) in Warburg flasks containing 2 ml. of the mixture and attached to manometers which were shaken, thus providing aerobic conditions. Most experiments were performed in a buffered avian Ringer phosphate, pH 7·4 (containing NaCl 0·97, $MgSO_4.7H_2O$ 0·025, $NaHCO_3$ 0·10, $NaHPO_4$ 0·1984 and KH_2PO_4 0·1815 per cent). All experiments were performed in mixtures of 3 parts diluent to 1 part of either whole semen or washed sperm resuspended to the original concentration. Total reducing substances in the mixtures were determined by the method of Hagedorn and Jensen[4] and fructose by the resorcinol method of Roe[5] as adapted to semen by Mann[6] in protein-free filtrates obtained by using barium hydroxide and zinc sulphate.

Although cock semen is notoriously poor in fructose[1], mixtures of cock semen and Ringer phosphate to which fructose was added in a concentration of 3·0 mgm. per ml. utilized fructose at the rate of 0·63–0·76 mgm. per 10^9 sperm during the first hour under semi-anaerobic conditions. Aerobically, 0·42–0·55 mgm. fructose was utilized by 10^9 sperm during the same period. Curves of utilization of fructose were not linear, presumably due to progressive inactivation of incubated spermatozoa and gradual depletion of the substrate. For example, in mixtures containing about $1{\cdot}5 \times 10^9$ sperm per ml. an average of 39 per cent of fructose was utilized during the first hour, 21 per cent during the second and a further 18 per cent during the third hour.

In order to determine whether cock spermatozoa, like those of bull and ram, utilize aldoses preferentially to fructose, cock spermatozoa were incubated in mixtures containing 3 mgm. fructose plus 6 mgm. of either glucose or mannose per ml. Surprisingly, in these mixtures no decrease in fructose whatever could be observed, and, in fact, the fructose content appeared to increase slightly. In a subsequent series of incubations carried out in diluents containing either glucose or mannose as the sole sugar, a definite accumulation of fructose was readily demonstrable. A typical experiment is illustrated in Fig. 1. In this experiment a 1 : 3 mixture of cock semen and Ringer phosphate, supplemented with 3 mgm. glucose per ml., during 3 hr. aerobic incubation at 40° C. produced 0·98 mgm. fructose per ml., which represents a conversion of more than 30 per cent of glucose into fructose. At the end of incubation the mixture contained more than twice as much fructose as glucose. The identity of fructose was confirmed by the yeast-fermentation test.

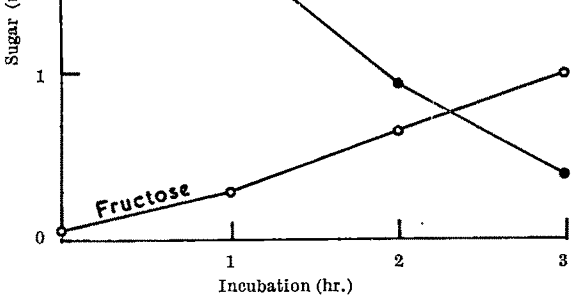

Fig. 1. Glucose utilization and fructose formation by diluted cock semen during aerobic incubation at 40° C.

Under the experimental conditions referred to in Fig. 1 the rate of formation of fructose was found to be approximately twice as high in aerobic as in anaerobic conditions. It was also found to be fairly independent of the initial concentration of aldose, at least over a certain range. When, however, the initial concentration of aldose was very small the rate of accumulation of fructose was much smaller. An average of 0·17 mgm. of fructose accumulated during the first hour in the presence of 2–6 mgm. aldose, but when the initial supply was limited to 0·8 mgm., only 0·06 mgm. fructose accumulated during the first hour and most of this disappeared during the second.

The formation of fructose in cock semen supplemented with glucose was found to be dependent on the presence of live spermatozoa. It was also demonstrated in suspensions of washed but motile spermatozoa. A pooled sample of semen was centrifuged, the packed cells suspended in Ringer phosphate, the suspension divided into two equal portions and both portions centrifuged. One portion was resuspended in half the original volume of seminal plasma and the other in the corresponding volume of Ringer phosphate. Samples of each were incubated with glucose and with mannose, each sugar at an initial concentration of 3 mgm. per ml. During the first hour 0·20 mgm. fructose was formed from either glucose or mannose in the presence of seminal plasma and 0·21 mgm. in the presence of Ringer phosphate ; after 3 hr., respectively 0·75 and 0·68 mgm. fructose had accumulated.

Since cock spermatozoa convert glucose and mannose to fructose the question arises whether they are also able to carry out the reverse reaction. The existence of such a reverse reaction could not be demonstrated, at least under aerobic conditions. In cock semen incubated for 3 hr. with 3 mgm. fructose per ml. 0·98 mgm fructose disappeared while the level of reducing substances other than fructose declined from 0·47 to 0·20 mgm. per ml. Under semi-anaerobic conditions the results were less clear. Here small but irregular amounts of non-fructose reducing material accumulated, but much of it proved to be non-fermentable by yeast.

This investigation was conducted during my tenure of a National Science Foundation Fellowship while on sabbatical leave from the University of California, Davis, California. The cordial and invaluable interest and advice of Dr. T. Mann throughout the investigation are gratefully acknowledged.

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Distribution of Newly Synthesized Deoxyribonucleic Acid in Mitotic Division

Firket and Verly recently presented[1] some results on the labelling of chromosomal deoxyribonucleic acid in chick fibroblast cells with tritiated thymidine. One of their conclusions is that their results support the hypothesis of the equal distribution of labelled, and hence newly synthesized, deoxyribonucleic acid between sister anaphase and telophase chromosome sets and contradict an earlier observation by Mazia and me[2] that this distribution may be decidedly unequal.

An inequality which exceeds that to be expected from the random distribution of the products of replication of different chromosomes and from the random distribution of decaying isotopic atoms suggests that there is an additional variant: a daughter chromosome may differ from its sister in the amount of newly synthesized deoxyribonucleic acid; in other words, the formation of daughter chromosomes from the maternal complex involves the random assortment of a small number of new and old units of deoxyribonucleic acid. This was the conclusion reached by us from an analysis which involved a mitotic system of six chromosomes and thymidine-^{14}C as the deoxyribonucleic acid marker[2].

A more direct approach to the problem was carried out by Taylor *et al.*[3]: tritiated thymidine was substituted for thymidine-^{14}C, thus permitting the autoradiographic analysis of single pairs of sister chromosomes rather than whole sets. Their conclusion was that sister chromosomes always shared equally in the deoxyribonucleic acid most recently synthesized, that the formation of daughter chromosomes did not involve the random assortment of the new and old structural units of the deoxyribonucleic acid of the mother complex. More recent experiments of mine strongly suggest, however, that these latter results are rather more complex than first appeared, that they are subject to a different interpretation from that offered by Taylor *et al.*[3], and that they by no means exclude the earlier conclusion of random assortment. In short, the question of the mode by which the mother chromosome is transformed into its two daughters is still unresolved and in need of further experimental elucidation.

The study of Firket and Verly[1] has a direct bearing on this question: if significant anaphase and telophase inequality of newly synthesized deoxyribonucleic acid is ruled out, then an equal partition of the material between daughter chromosomes is indicated. I should like to point out, however, that the experimental system chosen by these authors makes it virtually impossible to arrive at any significant quantitative conclusions. Unlike the experiment of Taylor *et al.*[3], the study by Firket and Verly looks at whole sets of post-metaphase chromosomes. In this respect it resembles our earlier investigation of the six-chromosome system (*Crepis capillaris*). In sharp contrast with the latter, however, the chick fibroblast cell presents a very difficult statistical problem indeed: with upwards of 60 chromosomes the number of cells that must be analysed in order to separate the random inequalities introduced by the independent behaviour of different chromosomes from those which might be introduced by the segregation of chromosomal sub-units is extremely large. Similarly, the number of grains in the autoradiographic image should be large enough to permit the statistical separation of random distribution and decay errors from biologically significant inequality. The actual results on which Firket and Verly base their conclusion[4] suggest that neither of these conditions is fulfilled. The number of cells analysed is 19, the average number of silver grains in the emulsion per cell is 47. In such a sample of a mitotic distribution system with 60 or more chromosomes one cannot hope to detect inequalities which are ascribable to differential labelling of sister chromosomes. The only conclusion which can be drawn from these results is that newly synthesized deoxyribonucleic acid is distributed between post-metaphase chromosome sets in chick fibroblast cells. The question of the equality or inequality of this distribution remains unelucidated.

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---

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I AGREE with Dr. Plaut that my results, though different from his, do not rule out the conclusions arrived at by him and Dr. Mazia. In fact, in the detailed paper[1] to which he refers, I wrote (p. 84): "Même si cette [Dr. Plaut and Mazia's] hypothèse sur la duplication de l'ADN est exacte, une telle déviation n'aurait qu'une chance infime d'apparaître dans les cellules de Poulet où le nombre de chromosomes est beaucoup plus élevé". I doubt the conclusions of their experiments for other reasons: namely, the inaccuracy of the limits of the field to be measured, the various possible errors in the quantitative assessment of radioactivity, and the contrary experiments by Taylor *et al.*[2].

I quite agree, however, that no definite conclusions have yet been reached about the mode of distribution of new deoxyribonucleic acid among daughter chromosomes. It is both a difficult and important problem with far-reaching consequences. If a deoxyribonucleic acid unit is defined as a molecule or group of molecules that are synthesized and tied together, the possible hypotheses are as follows:

(*a*) The number of deoxyribonucleic acid units per chromosome is small and there is a mechanism that ensures a perfectly equal distribution of newly synthesized labelled units and old units among daughter chromosomes. This implies a definite spatial relationship between these units (or, less likely, a system that can distinguish between new and old units of identical composition).

(*b*) The number of units is small and they are randomly distributed among daughter chromosomes. On the average, two sister chromosomes have an equal amount of new and old deoxyribonucleic acid, but some pairs may show a very unequal distribution.

(*c*) The number of units per chromosome is large and there is a random distribution.

(*d*) The number of units is large but there is a tendency for the newly synthesized units to move together.

The experiments of Taylor *et al.* tend to prove hypothesis (*a*). Plaut and Mazia's results[3], taken at their face value, point to (*b*) or (*d*). Mine agree best with (*a*) and (*c*). It should also be borne in mind that there may be no single pattern of universal application.

Contrary to what Plaut and Mazia[3] say, all these hypotheses are compatible with the Watson and Crick hypothesis of duplication of deoxyribonucleic acid molecules : a simple calculation shows there are usually several thousands of these per chromosome, so that a different order of magnitude is involved.

Crucial experiments are difficult to devise in this field where matters are complicated by errors due to the random decay of the isotopes and to the methods of quantitative assessment of radioactivity. It seems, however, that if hypothesis (*b*) is correct, we should find some unlabelled anaphase chromosomes (in a species where their number is large) after one premitotic synthesis in the presence of a radioactive precursor. If in such an experiment *all* chromosomes are labelled, hypothesis (*b*) becomes extremely unlikely. With the precise localization given by tritiated thymidine (but not with thymidine labelled with carbon-14), such an experiment now seems possible and I intend to try to tackle the matter shortly.

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Comparison of the Salivary Secretion of Both Parotid Glands in a Sheep

NUMEROUS workers have shown that the parotid glands of ruminants secrete saliva continuously, but only a small number of observations have been made on the secretion of both glands in the one animal. Scheunert and his colleagues[1] observed that the two parotids of sheep secrete independently of one another and considered it probable that the fistulated parotid secretes only a minimal amount of saliva. Colin[2] ascribed the differences in the secretion of the two parotid glands which he observed in the case of an ox to the preference on the part of the animal for chewing on the non-operated side.

In the course of investigations on the return of nitrogen to the rumen in the parotid saliva of sheep, the secretion from both parotid glands in a Merino wether was measured over fourteen days. Into each duct two cannulæ were inserted, one directed towards the gland, the other towards the orifice on the buccal mucosa. The free ends of the cannula on either side could be joined so that the saliva was able to flow into the mouth from one gland, while that from the opposite member was being collected. By reversing the opening and closing of the bridge from side to side, the daily secretion from each parotid gland was measured on alternate days. In this way the animal received the secretion from one gland at all times.

The collections were commenced three days after the surgical operation and continued for the following fourteen days. During this time the animal consumed the whole of its daily ration of 680 gm. of dry matter composed of sheep cubes, oat grain, oat chaff and lucerne hay. The animal had free access to water. Instead of giving the sheep a daily ruminal infusion of sodium bicarbonate to replace the sodium lost in the secretion from the operating gland, the remainder of the saliva collected, after samples had been kept for nitrogen analysis, was infused back into the rumen per cannulum at a rate simulating the natural flow.

For the duration of the experiment the animal was kept under the same environmental conditions to which it had been accustomed for the previous six months and maintained the same position in relation to its regular neighbours in the colony. It was attended by only one member of the department.

Under these conditions the daily volume was recorded for each gland on alternate days and the nitrogen content of the saliva determined by the micro-Kjeldahl method. The results are given in Table 1.

Table 1

Saliva	Left gland	Right gland
Total volume for 7 days (ml.)	16,665	17,468
Mean daily volume (ml.)	2,381 ± 94·3*	2,495 ± 94·3*
Range in daily volume (ml.)	1,992–2,745	2,268–2,775
Total nitrogen content for 7 days (mgm.)	2,076	2,007
Mean daily nitrogen (mgm.)	297 ± 10·6*	287 ± 10·6*
Range in daily nitrogen (mgm.)	257–327	251–341

* Standard error of mean

The mean daily volume of the left and right gland did not differ significantly (*t*, 0·86 on 12 degrees of freedom). Similarly in the case of the mean daily output of nitrogen, the left and right gland did not differ significantly (*t*, 0·66 on 12 degrees of freedom).

The mean daily volume of saliva and nitrogen content accord well with similar values recorded for sheep with permanent unilateral parotid fistulæ kept under the same feeding and environmental conditions at this Institute. Denton[3] has reported that the daily volume of saliva secreted by sheep with permanent unilateral parotid fistulæ is relatively constant on any one diet. However, the volume collected daily varies with the diet[4].

Both parotid glands continued to function for a further nine days until on the twenty-sixth day after the operation one of the cannulæ became dislodged. During the whole period of observation the animal did not appear to suffer any overt ill effect from the presence of the cannulæ in the ducts. It remained in good health, ruminated normally, and passed fæces of uniform consistency. Over the twenty-six days of observation the sheep gained 2·5 lb. in weight.

The procedure adopted of infusing the animal's own saliva back into the rumen as a continuous flow was designed to approximate the secretion of the saliva under normal physiological conditions and thus maintain the buffered fluid environment in the rumen. As an alternative I have observed that sheep with permanent unilateral parotid fistulæ will drink their own saliva, or that from another animal, and remain in a healthy condition without a daily supplement of sodium bicarbonate.

The significance of the salivary nitrogen contribution to the rumen under different dietary conditions will be discussed elsewhere.

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Desertomycin, a New Crystalline Antibiotic with Antibacterial and Cytostatic Action

A REPORT was recently published[1] of a new antifungal antibiotic, flavofungin, from a previously unreported *Streptomyces* strain, *Streptomyces flavofungini*. This species produces, besides flavofungin, another antibiotic. Its presence was demonstrated by the paper-chromatographic examination of the fermentation fluid and of the crude flavofungin. The *Streptomyces* strain originally isolated produces much more of this antibiotic than of flavofungin, in contrast to its natural variant, which synthesizes flavofungin more abundantly. The second antibiotic can be extracted from the fermentation broth as well as from the mycelium with organic solvents. We succeeded in obtaining hexagonal crystals from various solvent systems (Fig. 1). This new antibiotic was named 'desertomycin', after the source (African desert sand) of the *Streptomyces* strain which produces it.

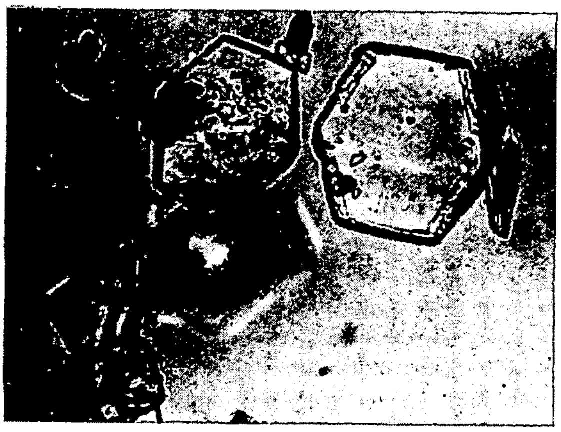

Fig. 1 Desertomycin crystals

Desertomycin is a uniform snow-white, glittering, crystalline product. Its tentative empirical formula is : $C_{33}H_{60-62}O_{14}N$. It melts at 189–190° C. The solubility in water or in absolute alcohols, ether and acetone is low, but it is higher in alcohols which contain some water. Its neutral aqueous solution is very stable. Desertomycin contains no sulphur, halogen, N-methyl or acetyl groups, but it has a C methyl group. The substance gives acetylated and hydrogenated derivatives ; it decolorizes a solution of permanganate or bromine and gives positive ninhydrin and Kuhn–Roth C-methyl tests.

Crystalline desertomycin was tested against a number of bacteria by a serial dilution method. The minimum inhibitory concentration varies between 5 and 25 μgm./ml. for various micro-organisms. The antimicrobial activity of desertomycin is shown in Table 1.

Table 1

Micro-organism	Inhibitory concentration (μgm./ml.)
B. subtilis, NTCC 6633	1–5
B. subtilis (streptomycin resistant)	1–5
B. subtilis (penicillinase producing)	1–5
B. megatherium	1–5
Staphylococcus aureus Duncan	10
Staphylococcus aureus (penicillin resistant) (three strains)	10
B. cereus 569	10
E. coli 111	10–25
E. coli S. (mouse-pathogen)	10–25
Staphylococcus aureus (mouse-pathogen) (two strains)	25
Staphylococcus aureus (four strains)	25
Staphylococcus aureus (poly-resistant)	25
Staphylococcus aureus (penicillin resistant) (five strains)	25
Micrococcus ureae	25
Enterococcus	>25
E. typhosa H	>25
E. coli commune	>25
Pneumobacillus Friedländer	>25
Pseudomonas pyocyanea	not inhibited

Desertomycin proved to be markedly toxic for mice. The intravenous, intraperitoneal, subcutaneous and oral *LD*50 of desertomycin in mice was found to be 1·35 mgm./kgm., 2·6 mgm./kgm., 5·3 mgm./kgm. and 12–15 mgm./kgm. body-weight, respectively.

Desertomycin exhibits a very significant cytotoxic effect. Our *in vitro* experiments show that it inhibits the life-activity of leukæmic cells and of Ehrlich ascites cells in a quantity of 0·7 μgm. and 10 μgm., respectively[2]. It exhibits a cytostatic (10 μgm.) and in higher concentrations (50–100 μgm.) a cytolytic action on fibroblast, HeLa and Crocker cells, studied by the tissue culture method (Kelner, B., *et al.*, personal communication). Once more the inhibition of the growth of bacteria is seen to be connected with the inhibition of tumour cells.

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Adrenalectomy and Tissue Amines

WE have recently suggested[1] that the secretion of the adrenal cortex exerts a functional control over the levels in tissue of both histamine and 5-hydroxytryptamine. This evidence was obtained by injecting synthetic corticosteroid substances into normal rats as well as into rats in which tissue histamine had been previously depleted. Further experiments have now been carried out on animals the adrenal glands of which have been removed before drug treatment.

Groups of rats (100–125 gm. in weight) were bilaterally adrenalectomized and maintained for four days on a cube diet and either drinking water or normal saline solution. Other groups were mock-adrenalectomized and similarly maintained. The animals were then killed and several tissues extracted and tested for histamine and 5-hydroxytryptamine activity. Striking differences between the amine-levels in the groups were noted. Whereas the histamine-levels in the skin, ears, feet, liver and lung of adrenalectomized rats maintained on normal saline solution did not differ significantly from those of mock-adrenalectomized animals, the histamine-levels in these tissues of adrenalectomized rats maintained on water were increased two to six times. When cortisone (but not deoxycorticosterone acetate) was given to such animals, the histamine-levels in the tissues fell dramatically to normal levels or below. This is therefore a further demonstration of the control exerted by glucocorticoid substances on tissue histamine-levels, and as suggested by Schayer and his co-workers[2] these substances probably alter the rate of formation of histamine in the tissues. In a similar manner, there is a two-fold increase in the 5-hydroxytryptamine-levels in the tissues of adrenalectomized rats maintained on drinking water, and cortisone treatment restores these levels to normal. The changes in the 5-hydroxytryptamine-levels might be magnified if the experiment can be performed on histamine-depleted adrenalectomized rats maintained on drinking water, but such rats have not so far been available.

These results support our hypothesis[1]. They further show that the tissue-levels of both histamine and 5-hydroxytryptamine are in part inversely related to the sodium intake. The importance of the dietary sodium content when studying the effect of adrenalectomy on tissue histamine-levels was shown by Rose and Browne[3]; but neglect of this factor by later workers led to several conflicting results. In assessing the effect of corticosteroids on conditions of inflammation, conflict has also arisen due to lack of appreciation of the role of tissue amines in certain of these conditions and of the control exerted upon these amines by the hormones of the adrenal gland and their analogues. It is of interest that in the present experiments the fluctuations in the 5-hydroxytryptamine-levels in the rat follow those in the histamine-levels, and in this respect are similar to those noted already in other forms of stress such as weaning, pregnancy and hyperthyroidism[4].

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Lethal and Sterilizing Effects of Single and Fractionated Doses of Gamma Radiation on *Calandra granaria* L.

Two techniques for radiation disinfestation can be distinguished: the direct irradiation of infested products[1], and the indirect control of a pest species by the release of sterilized adults[2]. The successful operation of the first method necessitates complete and permanent reproductive sterilization accompanied by premature death; and the second, sterilization without seriously affecting the longevity of the released adults.

The susceptibility of a number of insect species to large single doses of gamma radiation has been examined[3]. Small daily doses of X-rays[4] and γ-rays[5] have been shown to increase the longevity of the flour beetle (*Tribolium confusum* Duv.). Again, the sterilizing dose for the parasitic wasp (*Habrobracon juglandis* (Ashmead)) does not cause permanent infertility when fractionated with suitable time intervals between treatments[6]. As part of a broader project to examine the radiation susceptibility of grain weevils, preliminary experiments were carried out to compare the effects of single and fractionated doses of γ-radiation on larvæ and adult *C. granaria*. Insects were irradiated with a cobalt-60 source providing a dose-rate of 6 × 10^3 r./hr. Cultures were maintained on preconditioned grain at 26° C. and 75 per cent relative humidity.

Table 1. The Effects of Irradiating Larvæ of *C. granaria* with a Single Dose of 4,012 rep and Five Repeated Doses of 802 rep on Adult Emergence, Survival and Progeny Production

Treatment	Batches, each of 450 larvæ	Mean No. of adults emerged	Adult survival four weeks after emergence (per cent)	No. of progeny
Control *A*	2	105·0±5·5	99·1± 0·9	2,187± 59
Control *B*	6	115·0±3·3	98·9± 0·4	2,208± 40
Intervals between repeated doses:				
1 day	2	103·0±5·0	97·0± 2·1	1,621±213
1 hr.	1	47	66·0	51
10 min.	1	5	20·0	0
1 min.	1	2	50·0	0
Single dose	4	2·5±1·0	23·3±14·5	0

In the first experiment, batches of larvæ in grain were treated with a single dose of 4,012 rep and others with five repeated doses of 802 rep; the time intervals between treatments were 1 and 10 min., 1 hr. and 1 day. The single dose was applied to samples containing equal proportions of 7–8, 8–9, 9–10, 10–11 and 11–12 day-old larvæ. Similar samples were used when the intervals between repeated doses were 1 hr. or less. With daily doses, the first treatment was given to 7–8 day-old larvæ and the last on the eleventh to twelfth day of their development. Two types of untreated controls were used: *A*, larvæ 7–8 days old when the first daily dose was given and *B*, equal proportions of larvæ covering the age-range. The adults which emerged after treatment were placed to oviposit on 100 gm. of grain for four weeks. Table 1 shows the effects of irradiation on the emergence of adults, their survival and production of progeny.

In a similar experiment, batches of 50 adults 7–12 days old were treated with a single dose of 5,666 rep and others with five repeated doses of 1,133 rep; the 1-hr. interval between treatments was omitted. Controls *A* and *B* were used as in the first experiment. After irradiation the adults were placed to oviposit on 100 gm. of grain and the number of survivors counted four weeks later. Progeny were recorded 7 and 9 weeks after inoculation (Table 2).

Table 1 shows that when young larvæ are treated with a single dose and with doses fractionated by intervals of 1 and 10 min., adult emergence is markedly reduced; more adults emerge when the interval is increased to 1 hr., while with daily doses emergence is unaffected. These results suggest the existence of a recovery process which becomes completely effective a few hours after treatment.

Table 2. The Effects of Irradiating Adult *C. granaria* with a Single Dose of 5,666 rep and Five Repeated Doses of 1,133 rep on Survival and Progeny Production

Treatment	Batches, each of 50 adults	Mean survival after four weeks (per cent)	Mean No. of progeny (weeks after inoculation)	
			7 weeks	Total at 9 weeks
Control *A*	8	97·5±0·8	1,083±88·0	1,720±112·0
Control *B*	14	97·0±1·0	1,106±51·0	1,766± 48·0
Intervals between repeated doses:				
1 day	4	97·5±1·9	14± 0·6	53± 5·4
10 min.	3	10·7±0·7	10± 0·4	12± 0·6
1 min.	3	11·3±2·4	12± 3·0	14± 4·3
Single dose	7	5·1±1·1	11± 0·6	12± 0·8

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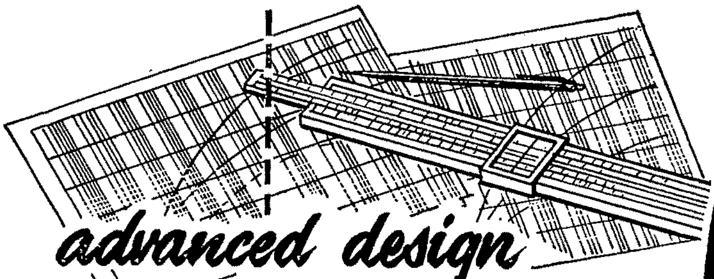

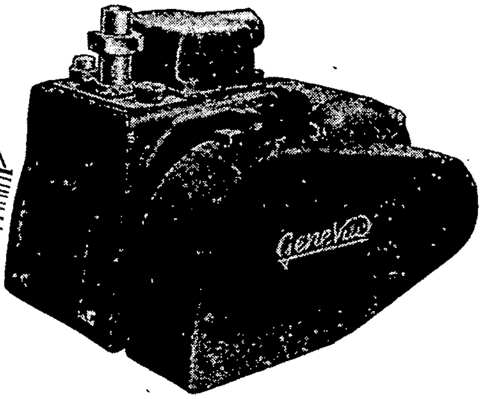

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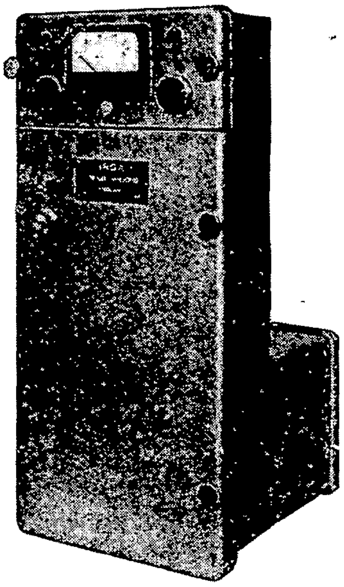

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Table 1 also shows that the survival of adults and production of progeny are similarly affected.

Table 2 shows that the survival of adults which are treated with fractionated doses is also similar to that obtained with a single dose if the interval between treatments does not exceed 10 min.; furthermore, after treatment with daily doses their survival is similar to the controls. Production of progeny, however, is seriously reduced by both single and fractionated doses, irrespective of their duration, and in this respect adults and larvæ differ markedly in susceptibility. However, the difference in progeny counts at 7 weeks and at 9 weeks suggest that fertility may reappear in adults receiving daily doses. The difference in behaviour of larvæ and adults may be attributed to the condition of gonadial development at the time of irradiation and warrants further investigation.

The present results are of importance in relation to the operation of the two techniques for radiation disinfestation. Thus, the efficacy of direct irradiation of infested products could be seriously jeopardized by the use of repeated passes if intervals between doses are longer than a few minutes. On the other hand, an increase in longevity, obtained by using fractionated doses at daily intervals, could considerably increase the efficiency of insect control by the release of sterile adults provided permanent sterilization was achieved.

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Dosage-Mortality Curves for Houseflies Susceptible and Resistant to DDT

A recent paper by Hewlett[1] has directed attention to the fact that the slopes of dosage-mortality curves for houseflies resistant to DDT are less steep than those for houseflies susceptible to DDT; he explained this in terms of (1) the relation between the amount of DDT absorbed by flies and the external dose; and (2) a possible variation from fly to fly of the DDT exerting a toxic effect at the primary site of action, a variation brought about or intensified by enzymatic detoxification of DDT in resistant flies. An alternative explanation of the phenomenon would be that DDT resistance in houseflies is genetically controlled, and that very few of the strains of insects so far examined represent genetically pure lines.

Let us take the case of an insect the resistance of which is governed by a single incompletely dominant gene *R*. Possible genotypes are then *RR*, *Rr* and *rr*. Even if the fully susceptible *rr* genotype is eliminated in each generation, the progeny of the heterozygote cross *Rr* × *Rr* will consist of 25 per cent of fully susceptible individuals. Unless, therefore, a pure line of *RR* constitution can be isolated from its allelomorphs, a dosage-mortality test of flies of a given generation will show a response of individuals ranging from complete susceptibility to the highest resistance expressible by the gene in question. Since in Nature the occurrence of resistance genes is normally so low that in an average sample of wild insects none will be found, the control will therefore represent a purer line of susceptibility than the resistant does of resistance. The difference in the slopes of the two dosage-mortality curves is therefore representative principally of the difference between the pure and the impure samples.

In the case of polygenic resistance, due to a number of weak genes acting together—to which type of resistance most cases of housefly resistance apparently belong—the picture is similar, but less simple. Let us take the case of two independently segregating partially dominant resistance genes *R* and *P*. There are then nine different possible genotypes, ranging from the highest resistance *RRPP* to the lowest (fully susceptible) *rrpp*, all of which may appear in any new generation. Given three genes, 27 possible combinations may occur. Separation of the genotypes is then virtually impossible, for any mass selection technique of exposure of a given generation to insecticide may still leave some heterozygotes alive, which will give rise to susceptibles and further heterozygotes at the next generation.

In the case of a pure line the difference between the *LD*0 and the *LD*100, that is, the slope of the curve, will be dependent entirely upon the inherent errors in the methods of sampling and testing, plus a certain fly-to-fly variation. In the case of a mixed strain, this difference will obviously be greater by the extent to which the component genotypes differ one from another. However, the establishment of a greater number of points on the dosage-mortality curve, that is, by testing a greater number of dosages intermediate between *LD*0 and *LD*100, may lead to the resolution of the gently sloping resistance curve into several parallel curves equal to the number of the genotypes present.

Fig. 1 shows the three separate log-probit regression lines for the three genotypes of the Western Sokoto strain of *A. gambiae* exposed to various concentrations of gamma-BHC. Resistance to dieldrin and BHC has been shown to be monofactorially inherited and incompletely dominant in this strain[2]. Super-imposed on these three regression lines is the graph for an F_2

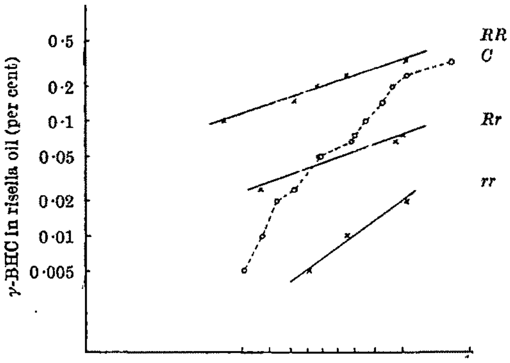

Fig. 1. Log-probit regression lines for susceptible (*rr*) hybrid (*Rr*) and resistant (*RR*) strains of *A. gambiae* exposed for 1 hr. to varying concentrations of gamma-BHC in risella oil and calculated percentage mortalities in a theoretical F_2 generation composed of 25 per cent susceptibles, 50 per cent hybrids and 25 per cent resistants (*C*) •

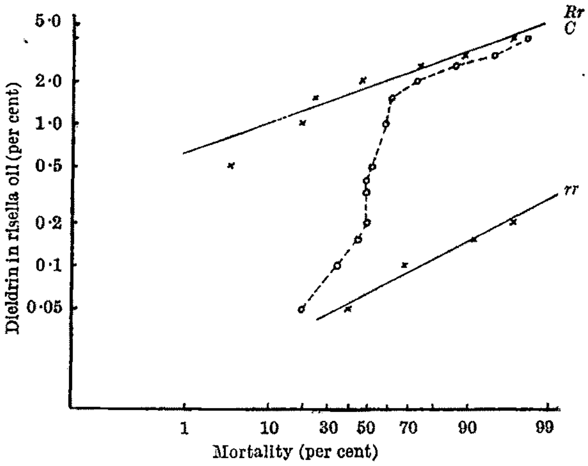

Fig. 2. Log-probit regression lines for susceptible (*rr*) and hybrid (*Rr*) strains of *A. gambiae* exposed for 1 hr. to varying concentrations of dieldrin in risella oil and calculated percentage mortalities in the theoretical backcross offspring (50 per cent susceptibles and 50 per cent hybrids) of a hybrid to the susceptible parent (*C*)

generation, composed of the theoretical 25 per cent susceptibles, 50 per cent hybrids and 25 per cent resistants, based on the actual mortalities recorded for the separate strains. A tripartite segregation of this graph is indicated though not too obviously and the points could be taken as lying on a single straight line. The explanation for this is that the degree of resistance to gamma-BHC is of a comparatively low order (some thirty times) and the gaps between the *LD*100 of the susceptibles and *LD*0 of the hybrids and *LD*100 of the hybrids and the *LD*0 of the resistants are very small. Resistance to dieldrin is much higher (some 800 times) and Fig. 2 shows the regression line for the theoretical offspring of the backcross of hybrids with the susceptible parent (50 per cent susceptibles and 50 per cent hybrids) based on mortalities recorded among susceptible and hybrid strains. A definite step in the line separating the susceptible part of the population and the hybrid part is apparent, where an increase in dosage produces no increase in kill (0·1–0·4 per cent dieldrin). As the degree of resistance to dieldrin is so high it is not possible to show the regression line for the resistant strain on this graph, where mortalities have been recorded after one hour's exposure to various concentrations of the insecticide. At this exposure time no kill at all is recorded with the resistant strain even on a saturated solution of dieldrin in risella oil. It will be seen from these graphs that on taking a sample of a resistant population produced by mass selection, the difference between the *LD*0 and the *LD*100 would be very much greater than in the case of any of the component lines.

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The paper of mine referred to pointed out that it was not yet possible to say whether the two effects discussed would account for the whole of the differences between the slopes of probit–log-dose lines for houseflies resistant and susceptible to DDT. Additional genetic heterogeneity in strains of resistant flies could, it seems, operate side by side with the other two effects in reducing the slopes of the lines; it might also intensify the second of the other two effects. When applied to resistant flies with DDT, *bis*(*p*-chlorophenyl) methyl carbinol synergizes the action of the DDT by depressing its enzymatic detoxification[1,2], and at the same time increases the slope of the line relating probit mortality to the log-dose of DDT[2]; this strongly suggests that the detoxification mechanism is directly concerned in depressing the slope of the line for DDT without synergist, as discussed in my paper.

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Ecology of the Louse *Lepidophthirus macrorhini* Enderlein 1904 on the Elephant Seal *Mirounga leonina* (L.)

The Australian National Antarctic Research Expeditions have maintained a station since 1948 on Macquarie Island, which is situated in the South Pacific, 54° 30′ S., 159° E. Through the courtesy of the director, Mr. P. G. Law, a visit was paid to the island in December 1957. This afforded an opportunity to obtain some information on the ecology of the louse *Lepidophthirus macrorhini* Enderlein 1904 which infests the elephant seal, *Mirounga leonina* (L.). Living lice were brought back to the laboratory for study by keeping infested hind flippers in a refrigerator.

Unlike other species of lice, *L. macrorhini* forces its way into the skin and creates a burrow under the stratum corneum of the epidermis. Single nymphs or adults were found in these burrows, usually with the posterior tip of the abdomen visible. Occasionally the burrows were half an inch in length. In addition, a copulating male and female were found in one burrow, and in two others, each inhabited by a single female, an egg was found. When the elephant seal moults the stratum corneum of the epidermis is shed intact with hairs attached. Although some lice are lost at this time many remain, since only the roof of the burrow which they inhabit is removed.

Pup seals were found to be the most heavily infested and the region of densest infestation was the hind flippers. From examinations made while the pups slept on the beach, it appeared that all were infested with lice.

The skin temperature of elephant seal pups and bulls (2–7 years old) resting on the beach was found to be between 27° C. and 34° C. Two pups were driven into the sea, after their skin temperatures had been taken, and restrained in 3 ft. of water by a lassoo around the neck. On entering the water their skin temperatures dropped to between 10° C. and 12·5° C., that is, a few degrees above the temperature of the sea, 8·5° C. These observations agree with those of Irving and Hart[1] on the harbour seal *Phoca vitulina* and the harp seal *Phoca groenlandica*.

In the laboratory it was found that the lice became inactive either in air or water at 10° C. When placed in moist air at 29° C., after an exposure to low temperatures for several days, normal activity did not return until after a few hours. Their oxygen consumption in air at 10° C., measured by a Warburg apparatus, dropped to at least a fifteenth of that at 33° C., and they survived a five-day immersion in sea-water at 10° C. which was only about 7 per cent saturated with oxygen (0·53 ml. oxygen per litre). Thus, at low temperature their metabolic rate was considerably reduced. It therefore appears likely that the skin temperature of the host is the primary factor which influences the growth of a population of these lice and that the main increase occurs when the skin temperature is highest, namely, when the elephant seal is on land. As a consequence, the age group which spends the longest continuous period ashore might be expected to become the most heavily infested. Pups comprised this group at Macquarie Island in December 1957.

It has been suggested that when the seal is at sea the lice obtain oxygen from a film of air trapped around the seal's body[2]. Examination of pups restrained in the sea showed that no film of air was trapped around the body, nor was one seen when the hind-flippers of pups, anæsthetized with chloral hydrate, were immersed in sea-water. Numerous small bubbles were held at the base of the hairs, in the orifice of the follicle, but were easily removed by gently running the fingers over the body. However, air bubbles which were sometimes retained in the burrows were not so easily removed.

Another suggestion has been that oxygen is obtained from air bubbles or from a film of air trapped between the characteristic setæ and scales found on this type of louse[3]. When lice were immersed in sea-water, a small bubble of air was occasionally attached to a seta but not necessarily to one of those surrounding the spiracles. More frequently, no bubbles were present and, as the cuticle of the louse was easily wetted, a film of air was not held around the insect. When completely wetted and immersed in fresh sea-water at about 10° C. the lice remained alive for more than two weeks.

As the cuticle is thin and transparent a microscopical examination of living lice in sea-water was made with transmitted light. Only abdominal spiracles were seen, with trachea leading from the anterior of the abdominal tracheal trunks to each of the limbs and the head. It was found that when a spiracular opening was surrounded by an air bubble regular contractions of the atrium commenced. When the bubble was removed these contractions ceased within a few hours. During this period no water was seen to enter the atrium, which was filled with a bubble of gas, some of which was occasionally expelled. As no other structure was seen which could have a respiratory function, it would appear that oxygen is obtained from sea-water by diffusion through the cuticle.

There appears to be no reason to doubt that sufficient oxygen can be absorbed through the cuticle. At the greatly reduced metabolic rate associated with the lowered temperature in sea-water, little oxygen would be required and the surface waters in the sub-Antarctic are usually more than 80 per cent saturated with it[4]. Moreover, the surface area of the cuticle of these lice is greatly increased by deep clefts in the intersegmental regions of the thorax and abdomen.

One function of the setæ, which in the living insect stand erect from the cuticle, is probably to maintain a space between the cuticle of the louse and the walls of the burrow in the seal's skin. This would enable a film of water to be maintained around the insect through which gaseous diffusion can take place. Also, any air bubble trapped in the burrow around the louse would be maintained and act as a gill.

It is hoped to continue these investigations and the co-operation of any biologist who intends to visit the sub-Antarctic would be most welcome.

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Natural Relationships of the Nitrogen-fixing Bacteria

In a recent publication, Hino and Wilson[1] describe the fixation of nitrogen by a bacterium strongly resembling *Bacillus polymyxa*. The significance of this finding should not escape notice, as it has an important bearing upon a long-standing controversy.

The existence of a Gram-positive, sporogenous form of *Azotobacter* was demonstrated by Löhnis and Smith[2] but their claims were disregarded. Much later, I showed[3] that many strains of *Rhizobium* pass through a Gram-positive, sporogenous phase, and expressed the opinion that this genus is related to *Bacillus polymyxa*. Afterwards, the work of Löhnis was confirmed and extended[4], and it was concluded that *Azotobacter* and *Rhizobium* are both specialized members of the Bacillaceae; with the important corollary that they were thus shown to be closely related to *Clostridium*, many species of which are capable of fixing nitrogen[5].

The members of the *Bacillus polymyxa* group differ from other aerobic sporing bacilli in possessing a clostridial spore and in producing gas from carbohydrates, but they share these characters with *Clostridium* and with the sporogenous strains of *Rhizobium* and *Azotobacter*. It now appears that they also share the ability to fix nitrogen.

Since it is very often stated that morphology is of limited value in the classification of bacteria, it is worth placing on record that the evidence which led me to the conclusion that *Bacillus polymyxa* is closely related to the nitrogen-fixing bacteria was almost entirely morphological.

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Growth-promoting Activity of Potato Tuber Extracts in the Coleoptile Straight-Growth Test: Quantitative Aspects of Indoleacetic Acid Detection

THE development of relatively simple techniques for the chromatographic separation of growth-active fractions from plant extracts, and their detection by chromogenic reagents, has led to the conclusion that indoleacetic acid and other indole compounds are the principal naturally occurring growth substances, as detectable in the coleoptile straight-growth test. In many instances, however, the characterization of growth-active fractions as indole or non-indole compounds has been based on insufficient evidence, or lack of awareness as to the sensitivity or specificity of the techniques used. For example, the growth activity in extracts of potato tubers has been ascribed to the presence of several indole compounds[1-3], yet no single investigator has demonstrated a correlation between colour reaction and biological activity for chromatograms developed in a number of solvent systems.

During the course of an investigation into the growth-substances present in developing and stored potato tubers, it was found that in the ether fractions from approximately fifty separate ethanol extracts there was present only one promoter of coleoptile growth. This ran at the position of indoleacetic acid in *iso*propanol : ammonia : water, butanol : ammonia: water, butanol : acetic acid : water, and ethanol : formic acid : chloroform : water solvents. Nevertheless, even when a 500 gm. fresh weight equivalent was chromatographed on a 10 cm. wide paper and strips from this sprayed with Ehrlich's reagent a colour reaction was not given. The failure of the growth-substance to give an indoleacetic acid colour reaction with chemical reagents, even though it appeared to be identical with the indoleacetic acid from chromatographic evidence, was investigated further as it seemed possible that the amount present might be below the minimum quantity detectable with such reagents. Known quantities of indoleacetic acid were distributed over 3 cm.^{2} areas of filter paper and sprayed with reagent; from 0·2 to 0·5 μgm. indoleacetic acid gave a faint, transient colour with Ehrlich's reagent and 5 μgm. was required to give a strong, more permanent colour. Salkowski's reagent was slightly less sensitive. From the results of bio-assay and assuming that the promoter was indoleacetic acid, it was determined that a little less than 1 μgm. would be present in the 500 gm. equivalent tuber fraction and, as 10 cm. wide paper was used, this was distributed over an area of 30 cm.^{2}. This concentration, although giving considerable growth stimulation on bio-assay, would therefore be well below the limit of detection with chemical reagents. In order to be certain of getting a colour reaction, if the promoter was indoleacetic acid, it was calculated that the extract from 3 kgm. of tubers would have to be localized in an area of 3 cm.^{2} of paper. This was achieved by repeated chromatography and elution, and with Ehrlich's reagent a colour reaction typical of indoleacetic acid was given. Recently it has been shown that some sugars[4] and other compounds[5], probably leucoanthocyanidins, give colour reactions which may be confused with those given by indoleacetic acid. These substances were not responsible for the colour reaction of the potato extracts.

It is clear from the results relating to the sensitivity of the chemical reagents used for the detection of indole compounds that care must be taken to use a sufficient quantity of material in order to detect a chromogenic reaction. The failure of certain other workers to obtain colour reactions at growth-promoting zones running at the same position as indoleacetic acid on chromatograms might well be due to lack of material.

In the present investigation it appeared that the only ether-soluble growth promoter of potato tubers was indoleacetic acid. The discrepancies between the present results and those of earlier workers, who reported two or three further indole compounds, may be a consequence of differences in extraction technique. In this work material was frozen solid, powdered and allowed to thaw in ethanol. Under these conditions the tissue remained perfectly white throughout extraction. *p*H adjustment was not made during extraction or in the separation of an initial ether fraction; but a further ether extract, made at *p*H 3, yielded no other promoters.

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δ-Acetylornithine : a Constituent of some Common Grasses

Two acetylornithines have been identified as natural products. α-Acetylornithine is accepted as an intermediate in the major pathway in the biosynthesis of ornithine from glutamic acid in *Escherichia coli* and has been isolated from culture filtrates of a mutant strain of this organism requiring ornithine[1]. δ-Acetylornithine was isolated somewhat earlier from the roots of *Corydalis ochotensis* by Manske[2]. It is also present in *Corydalis bulbosa*, and has been isolated as its dihydrochloride from the fern, *Asplenium nidus*[3]. In a private communication, Prof. K. Mothes tells me that he and Dr. G. Reuter have extended Manske's findings and have shown that δ-acetylornithine is present in large amounts in nearly all the members of the Fumariaceae (of which *Corydalis* is a member) that they have examined.

No information is as yet available to indicate the way in which δ-acetylornithine is implicated in intermediary plant metabolism. This may be due largely to the unsuitable nature for metabolic experiments of the plants from which it has been isolated. Therefore it seems appropriate to report that the amino-acid has now been identified as a constituent of a number of common grasses of the tribe Festuceae. In order to confirm its chemical character it was isolated from a representative member of these species, *Brachypodium sylvaticum*.

By means of cation-exchange resin ('ZeoKarb' 215) and paper partition chromatography, approximately 50 mgm. of δ-acetylornithine were isolated from an aqueous ethanolic extract of 500 gm. of macerated leaves of *Brachypodium*. The identity of the substance was confirmed by elementary analysis (found : C, 48·0 ; H, 8·2 ; N, 15·8 ; calculated for δ-acetylornithine, $C_7H_{14}O_3N_2$: C, 48·3 ; H, 8·0 ;

N, 16·1 per cent), and by comparison with authentic samples of δ-acetylornithine obtained from Profs. K. Mothes and A. I. Virtanen. The substance from *Brachypodium* was inseparable from δ-acetylornithine when run on paper chromatograms developed in four different solvent systems. In contrast, it could be separated from α-acetylornithine (kindly supplied by Dr. H. J. Vogel) on chromatograms developed in *n*-butanol/acetic acid mixture and in 70 per cent (v/v) *n*-propanol. The isolate had a melting point of 265° C.; no depression of the melting point resulted when the isolate was admixed with δ-acetylornithine (melting point, 265–266° C.). When hydrolysed with *N* hydrochloric acid at 100° C. for 24 hr., the isolate gave rise to ornithine which was identified chromatographically.

Although δ-acetylornithine is normally a major component of the free amino-acid pool of the members of the Fumariaceae, it was a relatively minor component of *Brachypodium* and, in the grasses examined, it never accumulated in concentrations comparable with those of certain of the common protein amino-acids. δ-Acetylornithine was not present in the leaves of two common cereals examined. Small amounts of another amino-acid, provisionally identified as α-aminoadipic acid, were found in the extracts of most of the grasses. The relative amounts of δ-acetylornithine and α-aminoadipic acid present in each species are listed in Table 1. Occasionally β-alanine or pipecolic acid also was found in an extract together with many of the normal protein amino-acids.

Table 1. RELATIVE AMOUNTS OF δ-ACETYLORNITHINE AND α-AMINOADIPIC ACID IN EXTRACTS PREPARED FROM LEAVES OF VARIOUS GRASSES

Species	δ-Acetylornithine	α-Amino-adipic acid	Other acids
Agropyron repens	*	*	β-Al: *W*
Brachypodium sylvaticum	*M*	*W*	*
Bromus carinatus	*	*W*	*
Dactylis glomerata	*	*W*	PA: *M*
Festuca heterophylla	*W*	*W*	*
Lolium perenne	*T*	*W*	β-Al: *W* PA: *M*
Poa glauca	*S*	*W*	*
P. nemoralis	*M*	*W*	*
P. alpina	*W*	*W*	*
P. pratensis	*M*	*W*	*
Puccinellia maritima	*M*	*	*
Barley (*Hordeum vulgare*)	*	*W*	*
Oats (*Avena sativa*)	*	*T*	*

Key: *S*, relatively large amount; *M*, moderate amount; *W*, small amount; *T*, trace amount; * not detected; β-Al, β-alanine; PA, pipecolic acid.

The ready availability of seeds of a number of the grasses investigated and the vigour with which they grow should make these species more suitable than the Fumariaceae for future study of the way in which δ-acetylornithine metabolism is related to the basic, well-established patterns of nitrogen metabolism in the higher plant.

My thanks are due to Miss J. Chessun for technical assistance.

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Photoperiodic Response of the House Sparrow, *Passer domesticus*

FORTY-SIX male sparrows were divided into two groups and placed in light-tight cages 6 ft. × 6 ft. × 6 ft.

Group 1. Twenty-four birds were given a photoperiodic treatment of 7 hr. light and 17 hr. darkness per 24-hr. period. Light was from two 40-watt daylight fluorescent tubes which gave never less than 7 ft.-candles in any part of the cage. Group 2. Twenty-two birds were given a photoperiodic treatment of 1 hr. light and 23 hr. darkness per 24-hr. period. Light was from a single 15-watt incandescent bulb which gave 1 ft.-candle or less on perches and floor.

The experiments were started in February 1957 and two specimens were taken from each group every month. Testis volume was obtained from measurements of the axes of the organs immediately upon dissection and afterwards sections were cut at 5μ and stained to show the stages of spermatogenesis. In addition, as many wild controls as it was possible to obtain were collected in the immediate environment and were given the same histological treatment as experimentals.

The testis volume and stage of spermatogenesis of controls, group 1 and group 2 are shown in Figs. 1 and 2. It is concluded that:

(1) The minimal threshold-level in respect of photoperiod is down to at least 1 hr. in this species.

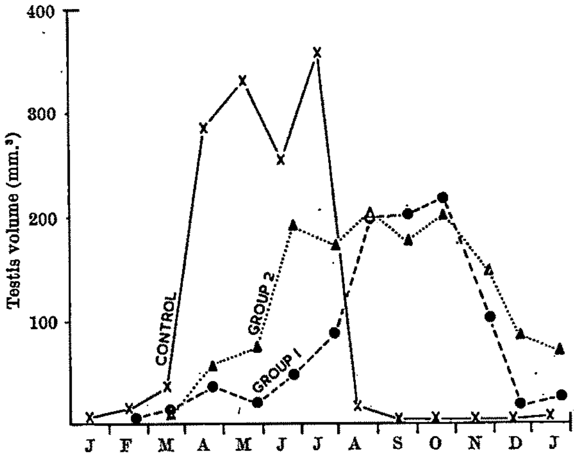

Fig. 1. Testis volume. Groups 1 and 2, average of two specimens each month. Control, average of all specimens each month

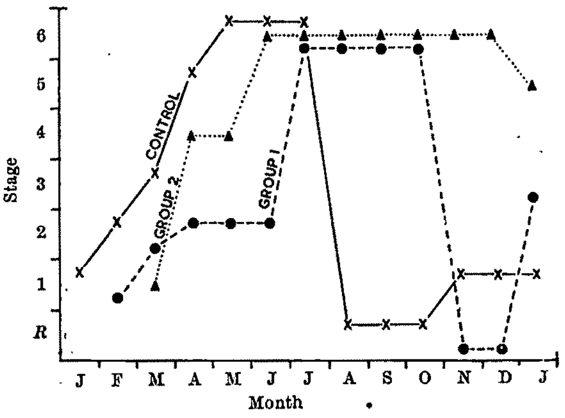

Fig. 2. Spermatogenesis. Groups 1 and 2, maximum stage of spermatogenesis of two specimens each month. Control, maximum of all specimens each month

This level is very much lower than has previously been recorded for any other bird. Bartholomew[1] considered 10 hr. to be close to the minimal level for the sparrow, but subjected birds to this photoperiod for only 46 days.

(2) The effectiveness of a photoperiod is dependent not only on its length but also on the duration of its application. In both group 1 and group 2 only slight testicular response was evident after 4 months and 3 months respectively. In estimating the minimal photoperiodic threshold for any bird, therefore, it appears necessary to conduct experiments for at least 6 months.

(3) The relationship between length of photoperiod and time of maximum testicular response, that is, production of spermatozoa, does not seem to be a straight-line correlation. Further research may show this relationship to be parabolic, with the minimal response centred at a 7- or 8-hr. photoperiod and the response increasing from this low in both directions.

(4) The duration of production of spermatozoa appears to bear a certain inverse relationship to the length of the photoperiod. On 1 hr., spermatozoa were produced for 214 days, with 7 hr. for 122 days and under natural conditions for 98 days. A relationship between photoperiod and duration of spermatogenesis has been noted by Burger[2] for the starling. In this bird the rate of testicular activation increased from 8·5 to 24 hr. but the duration of spermatogenesis was maximum at 12·5 hr. and decreased for both longer and shorter photoperiods. The results given here are in contrast with those of Burger because a 1-hr. photoperiod, when compared with a 7-hr., not only extended its duration but also induced a more rapid spermatogenetic activation.

The extension of the potential breeding season in this bird by artificial means is only the third recorded case known to me. Wolfson[3] reported the maintenance of active testes in Fringillid birds for almost a year on 12 hr. and on 20 hr. starting on April 6.

(5) The inherent tendency to testicular involution can be modified by photoperiodic treatment. The tendency seems to be 'put off' by short photoperiods (see 4). Furthermore, recovery from collapse is more rapid under a short photoperiod and this is shown in group 1, where only 1 month after complete regression, spermatogenesis had proceeded to stage 3, while the testes of controls were at stage 1. This conclusion is in agreement with the findings of Burger[2] for the starling and Wolfson[4] for the junco and white crowned sparrow.

(6) The testicular cycle of this bird is under the control of two separate mechanisms, one stimulatory and the other inhibitory but both under photic control. The separateness of these two mechanisms is indicated in that more rapid activation of the testes does not necessarily result in a rapid regression. Group 2 showed a more prompt response than group 1 and attained testicular volumes comparable with the latter but had not regressed as completely by the end of the experiment. It seems reasonable, therefore, to postulate separate mechanisms. The results here suggest that there is some direct relationship between the amount of inhibitory substance produced and the photoperiod; for example, very little is apparently produced by 1 hr., as regression was only partial, sufficient for regression by 7 hr., but as re-activation of the testis is rapid, its effect must be soon destroyed, and most under natural conditions when, after collapse in August, reactivation does not occur until November or December. There is, therefore, some suggestion that the effectiveness of the inhibitory substance is destroyed by long nights.

The results of these experiments are very similar to those I have already obtained in respect of the pigeon *Columba livia* (unpublished). Further experiments are, of course, necessary, and the following are at present in progress: 1 hr. light and 23 hr. darkness and 4 hr. light and 20 hr. darkness, both with an intensity of not less than 7 ft.-candles; 4 hr. light and 20 hr. darkness with an intensity of 1 ft.-candle or less on perches and floor. It is hoped to publish a full report of these results together with those of the new experiments when the latter are completed.

This work was carried out while I was the holder of a National Research Council of Canada Post-Doctorate Fellowship. I wish to express my appreciation to Dr. H. I. Battle, for providing laboratory and other research facilities in the Department of Zoology, University of Western Ontario.

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Department of Zoology,
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March 19.

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The Hood of the Hooded Seal, *Cystophora cristata* Erxl.

It is well known that the male of the hooded seal, *Cystophora cristata*, can inflate its hood, which is the greatly enlarged skin of the snout. It is also known that the male hooded seal can extrude an assumed pair of fiery red bladders or balloons through his nose. The presence in the nose of two evertible cœca, which would apparently be turned inside out in much the same way as glove-fingers, was claimed by Mohr[1] from the study of a museum specimen.

Having spent a few seasons on Norwegian commercial sealers in East Greenland waters I am able to throw additional light on this particular feature. Although I looked particularly for the evertible cœca, no such structures could be found on freshly killed animals. On several occasions I had the opportunity to examine males which were known with certainty to have extruded a fiery red bladder just prior to capture.

Having questioned several skippers and gunners, and having at last seen the phenomenon myself, I am now certain that one bladder only is extruded. Some of the skippers, who have excellent opportunities to observe the animals from the mast-head, state that when the bladder is beginning to be extruded it looks as if two are present, but, when fully inflated, one only is seen. It appears that the bladder is divided distally into two lobes, the whole structure in the inflated state being heart-shaped when viewed from above.

In males having a well-developed hood, the mucous nasal septum which divides the nasal cavity into two equal halves is also very well developed and is rather thick and elastic, the cartilaginous nasal septum remaining short. The extrusion of the bladder may be explained as follows: by closing one nostril, and by blowing out air through the nose, the mucous nasal septum is made to bulge into the opposite half of the nasal cavity and is extruded through the opposite nostril as a red bladder. The extrusion of this bladder appears to be confined to the breeding and mating season in the spring.

Nothing in the work of Brönsted[2] is thought to be contrary to the view expressed here.

It would be of interest to know if the male elephant seal, *Mirounga leonina*, the proboscis of which is similar to that of the hooded seal, can extrude a bladder through the nose in the same way.

Björn Berland

Directorate of Fisheries,
Institute of Marine Research,
Bergen. June 3.

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Genetic Hazard of Ionizing Radiations

In current estimates of the genetic hazard of ionizing radiations to man[1] [2] four important assumptions are made: (1) that the mutagenic effect of a given radiation dose to the gonads is independent of dose-rate; (2) that the relationship of mutation-rate to accumulated dose is linear; (3) that the spectrum of radiation-induced mutation is similar to the spectrum of spontaneous mutation, and (4) that a dose of about 30–80 rads induces as much mutation as occurs spontaneously per generation ('doubling dose'). Assumptions (1), (2) and (3) derive largely from experiments with *Drosophila*; assumption (4) derives in part from the fact that a spermatogonial doubling dose of this order was estimated for seven specific genes in the mouse from observations of the spontaneous mutation-rate[3,4] and from experiments[4] in which adult males were given a high X-ray dose at a high dose-rate (600 rads, 90 rads/min.), the validity of assumptions (1), (2) and (3) being presupposed.

However, Russell and Kelly[5] have recently stated that they have found a much lower induced spermatogonial mutation-rate at these loci when the dose of 600 rads was given as cæsium-137 γ-rays at a low dose-rate than when it was given as 250 kV. X-rays at a high dose-rate. This means that for mouse spermatogonia one can no longer make assumption (1) and that estimates of the doubling dose will vary with the conditions of irradiation. Since man is likely to resemble the mouse more than *Drosophila* in this respect one can no longer make assumption (1) for man. Most genetically effective radiation exposure of man is due to low doses accumulated over an appreciable fraction of the life-span; it therefore becomes important to have some estimate, however rough, of the mutagenic effect of radiation delivered to the mouse under conditions more nearly comparable with those of most human exposure.

During the past ten years we have been carrying out two such experiments. In the present experiment young adult male mice accumulate 37·5 rads as cobalt-60 γ-radiation over 35 16-hr. nights. They are placed with females immediately after exposure and are bred for up to two years, so the great majority of gametes tested were spermatogonia at the time of exposure. Progeny of exposed and control males are scanned for recessive mutation at the *a*, *b*, *c*, *d*, *se*, *p* and *s* loci and for dominant visible mutation at any locus. The stocks and techniques used have been described elsewhere[6]. The results are summarized in Table 1, together with those from our earlier experiment[6] in which radium γ-rays were used. They yield an estimate of 95 rads for the doubling dose for the seven specific loci, which is higher than previous estimates[1,3] by a factor of 2 or 3. However, the lower 95 per cent confidence limit[7] is only 10 rads and therefore the data do not warrant any change in assumption (4). More than anything else they show the enormous numbers of animals that must be raised in low-dose mutagenesis studies: clearly at least a million more mice must be scanned before we shall have an estimate of the spermatogonial doubling dose that approaches precision.

Table 1

Dose (rads)	Progeny scanned	Specific locus mutations *a*	*b*	*c*	*d*	*se*	*p*	*s*	Total	Dominant visibles
0	18,355*	0	0	0	1	0	0	1	2	0
0	99,372†	0	1	0	3	‡	1	1	6	2
37·5	10,024*	0	0	0	0	0	0	1	1	0
37·5	53,298†	0	2	0	3	0	0	0	5	1

* Data from ref. 6; radium γ-rays used.

† Includes data from ref. 3: cobalt-60 γ-rays used.

‡ Two of the *d*-mutants were also mutant at the closely linked locus *se*. These have been counted as single mutational events in the analysis.

These results have a bearing also on assumption (3). In our experiments *d* has been the most mutable locus, there having been as many mutations at this locus alone as at the other six loci together; but in his high-dose, high-dose-rate experiments Russell[4] found only six *d*-locus mutations among a total of 54, the most mutable locus being *s*, with 25 mutations. Thus in this small sample of loci the spectrum of mutation induced by a high acute dose, on one hand, differed from that of spontaneous mutation and mutation induced by a low chronic dose, on the other. Clearly the validity of assumption (3), as applied to larger samples of loci, requires further test.

T. C. Carter
Mary F. Lyon
Rita J. S. Phillips

Medical Research Council
Radiobiological Research Unit,
Harwell. June 4.

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Possible Autosomal Linkage in Man

Familial intestinal polyposis is known to be an inherited dominant disease[1]. Most families die out after a few generations as the condition frequently causes death before reproduction has occurred, and affected individuals often refrain from marriage because of the danger of passing the condition on to their offspring.

In New Zealand a pedigree is being studied which consists of nearly two hundred individuals covering six generations. This pedigree contains eight families segregating for polyposis. A preliminary investigation, designed to test for possible linkage relations, has suggested that the polyposis gene may be closely linked to the *MN* locus. The method used is that described by

Finney[2]. Of the eight families, one must be rejected as the parent with polyposis is group *M*, and in three families the parent affected with polyposis died before the investigation was begun and examination of the offspring is not sufficient to be able to determine the mating type with certainty. One further family of Finney's mating type 4 has only two offspring, one of which is group *MN* and so cannot contribute to the linkage test. The remaining three families appear in the analysis of Table 1, which follows Finney's scheme.

Table 1

Family	Mating type	*a*	*b*	*c*	*d*	$\lambda = \frac{1}{2}u_{11}$	$K_c = \omega_1$
III (1)	4	2	0	0	0	1·00	1·00
III (5)	4	0	1	3	0	6·00	6·00
III (8)	3	1	0	0	1	1·00	1·00
						$S(\lambda) = 8{\cdot}00$	$8{\cdot}00 = S(K_c)$

$$\frac{S(\lambda)}{\sqrt{S(K_c)}} = \frac{8}{\sqrt{8}} = 2{\cdot}828; \quad P < 0{\cdot}01 \quad (1 \text{ per cent point} = 2{\cdot}33)$$

An attempt has been made to include three 'uncertain' families using Finney's technique for test factors showing dominance, but as some of these families are now part-Maori in origin and the gene frequencies for *M* and *N* are not known for Maoris, the results can be only tentative. However, the significance of the results does not seem to be affected by the inclusion of these families using estimated gene frequencies, and an estimate of the recombination fraction shows that the linkage is close (probably less than 5 per cent).

This pedigree will yield further information during the next ten to twenty years as a number of families too young for any member to have developed polyposis have already been extensively examined for blood group and from time to time they will be examined for polyposis.

This work was financed by the Medical Research Council of New Zealand.

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Migration of Spleen Cells from Subcutaneous Implantation Sites

PARTICULATE matter and cells injected subcutaneously are normally localized at the site of injection, while the suspending medium diffuses outwards[1]. Exceptional behaviour might be expected of cells from the bone marrow and spleen, however, for these cells can become established in homologous tissues after intravenous injection into irradiated hosts[2]. On the other hand, the intravenous route of injection is more effective than the subcutaneous in procuring the functional survival of these cells, as judged by protection against lethal irradiation[3], and the adoptive transfer of immunity[4]. The continued production of a specific antibody by spleen cells was used in the present experiments, to determine their localization after subcutaneous implantation.

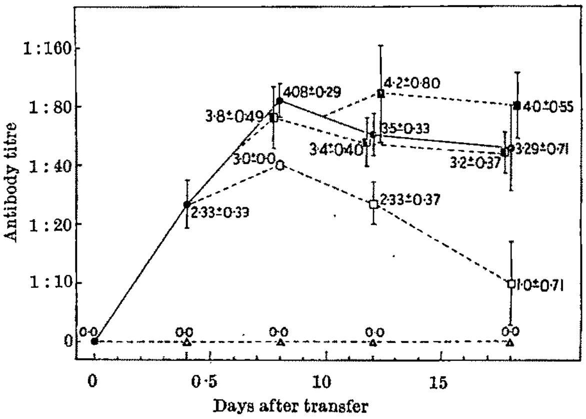

Fig. 1. Antibody titres of sera from host mice after transfer of spleen cells (means with standard deviations from 3–7 mice). Untreated cells, ●——●; subcutaneous site removed on fourth day, □- - -□; subcutaneous site removed on sixth day, ◧- - -◧; subcutaneous site removed on tenth day, ■- - -■; frozen-thawed cells, △- - - △

Spleen cells were transferred from immunized mice of the *CBA* strain into adult non-immunized hosts of the same strain. Immunization was carried out by intravenous injection of *Salmonella typhi* (H), according to Mitchison's procedure[5]. The spleen cells were suspended in saline and injected subcutaneously into the flank, at a dose equivalent to one whole spleen into each host. At intervals after transfer, the *H*-agglutinins in the serum of the hosts were titrated (Fig. 1). One group of hosts received frozen and thawed cells. In the other hosts the cells remaining at the subcutaneous injection site were either removed surgically after an interval, or were left undisturbed.

No antibodies were detected in the hosts after injection of cells that had been frozen and thawed, indicating that no significant quantities of antigen or pre-formed antibody had been transferred with the cells. The appearance of antibodies in the other hosts can therefore be attributed to synthesis by the transferred cells; antibody synthesis occurred, although at a lower level than after transfer of comparable cells by the intraperitoneal route[5]. Removal of the cells at the injection site on the fourth day after transfer was followed by a drop in antibody titre, whereas removal on the sixth or tenth day was without significant effect. It appears, therefore, that functionally active cells were still present at the subcutaneous site up to the fourth day, but that the active cells later migrated elsewhere—presumably into the regional lymph nodes.

Histological examination confirmed the absence of active cells from the subcutaneous site after the fifth day. The remaining lymphoid cells were gradually degenerating and dying, within a well-defined, generally encapsulated nodule. Holub has described similar nodules in the omentum of young rabbits after intraperitoneal injection of lymphoid cells[6].

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APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Lecturer (with a degree in physiology or veterinary surgeon) in the Department of Physiology—The Secretary, Royal Veterinary College, Royal College Street, London, N.W.1 (August 15).

Lecturer in Industrial Administration—The Registrar, Manchester College of Science and Technology, Manchester 1 (August 16).

Assistant Physicist (Basic or Senior grade), for duties concerned with routine radiotherapy physics and the clinical use of radioactive isotopes, with opportunities for research in the clinical application of radioisotopes—The House Governor, Charing Cross Hospital, London, W.C.2 (August 18).

Senior Lecturer (with a university degree, teaching and/or research experience together with a knowledge of tropical soils) in Soil Science in the Department of Agriculture, Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 22).

Lecturer (Grade I or II) in Plant Pathology in the Department of Agriculture, University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (August 25).

Lecturer in Chemistry; and a **Senior Lecturer in Education** at Fourah Bay College (University of Durham), Sierra Leone—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 29).

Lecturer in Mathematics (Pure Mathematics) at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, August 29).

Assistant Lecturer (preferably with an interest in research in the general field of ionized gases) in Physics—The Registrar, University College of Swansea, Singleton Park, Swansea (August 30).

Junior Lecturer in Mathematics—Professor E. C. Titchmarsh, Mathematical Institute, The University, Oxford (August 31).

Physicist, Senior Scientific Officer grade (with a good honours degree in physics, general physical experience, and a knowledge of radiochemical equipment), in the Scientific Branch at County Hall, for research work on properties of materials and in the field of health physics—Medical Officer of Health (PH/D.1/A), County Hall, London, S.E.1 (September 1).

Physicist (with a university degree in science, applied science or engineering, or a technical college diploma or equivalent qualifications and preferably some practical experience in instrumentation, electronics or vacuum techniques) in the Division of Food Preservation and Transport, C.S.I.R.O., Homebush, New South Wales, Australia, to participate in investigations of the relation between the vapour pressure and the water content of biological materials, and in the development and assessment of objective methods for measuring differences in colour between samples of particular foodstuffs—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 300/207 (September 1).

Senior Research Assistant (Ph.D. standard and preferably some experience of electronics and/or low temperature work) in Physics, for a programme of work on the magnetic properties of thin films—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (September 1).

Research Assistant or Junior Fellow in Aeronautical Engineering—The Registrar and Secretary, The University, Bristol (September 8).

Lecturer in Philosophy at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 15).

Students and Fellows, for research in various topics in physical metallurgy, mainly related to nuclear energy, and including irradiation damage, brittle fracture, corrosion of uranium, transformations in uranium alloys, ageing in aluminium alloys, and deformation of semiconductors—Prof. J. G. Ball, Metallurgy Department, Imperial College of Science and Technology, London, S.W.7 (September 19).

Senior Lecturers (2) and a Lecturer in the Department of Biochemistry, University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 30).

Senior Research Officer (graduate, with research experience in amino-acid and protein chemistry) in Biochemistry, to undertake research on the proteins of the wheat grain—The Registrar, University of Melbourne, Carlton N.3, Victoria, Australia (September 30).

Lecturer in Agricultural Chemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 10).

Research Students and Fellows in Physics at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 15).

Assistant Professor or Associate Professor (with a Ph.D. degree in organic chemistry, and preferably research interests in the chemistry of natural products) in the Department of Chemistry—Prof. C. A. McDowell, Department of Chemistry, University of British Columbia, Vancouver 8, B.C., Canada.

Biochemist, for research on problems connected with the composition, enzyme activity and metabolism of healthy and infected leaves at different stages of growth—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Biochemist (preferably with postgraduate experience), for research into lipoprotein metabolism in childhood diabetes—H. B. Salt, Department of Biochemistry, Children's Hospital, Birmingham 16.

Chemical Engineers (with an honours degree or equivalent and significant experience in chemical engineering research), to develop processes and pilot plants in connexion with radioactive substances—Group Recruitment Officer (1179/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Experimental Officer (with a good knowledge of general laboratory technique and experience in the research field) at the Milk Marketing Board's Deep Freeze Unit at Northampton, to be responsible for the handling and freezing of bull semen—The Personnel Officer, Milk Marketing Board, Thames Ditton, Surrey.

Graduate Organic Chemists (2) to join a team investigating a problem in the field of wood chemistry—The Director, Arthur D. Little Research Institute, Inveresk Gate, Musselburgh, Midlothian, Scotland.

Lecturer, Grade B (graduate of a British university), in Mathematics—The Clerk to the Governing Body, Battersea College of Technology, London, S.W.11.

Librarian (under 55, with an honours degree in science and preferably some training in geology) in the Geological Survey Department, Federation of Nigeria, for duties which include organizing, indexing and maintaining the Department's library, map collection and technical records; assisting in the collection and abstracting of information on geological research and in the preparation of Geological Survey publications—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.105/14/010/T.

Mechanical Engineer (professionally qualified and with sound experience in the maintenance and operation of engineering plant and equipment), initially to inspect, accept and commission mechanical plant for the 7 GeV. Proton Synchrotron and, later, to organize and control operation, maintenance and modification of that plant—Group Recruitment Officer (1168/2), Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Research Assistant (physicist, preferably with research experience and a knowledge of electronics), for work on development of methods of temperature measurements in shock tubes—Dr. A. G. Gaydon, Chemical Engineering Department, Imperial College of Science and Technology, South Kensington, London, S.W.7.

Research Assistants in the Department of Chemistry, for experimental work on the thermodynamic properties of mixtures—The Registrar, The University, Reading.

Senior Lecturer (well qualified in physics and prepared to teach to the level of the Diploma in Technology in Applied Physics) in Physics—The Principal, Brunel College of Technology, Woodlands Avenue, London, W.3.

William Dick Chair of Veterinary Surgery—The Secretary, The University, Old College, South Bridge, Edinburgh 8.

Zoologist or Physiologist (graduate), to assist in the British Empire Cancer Campaign research on the biology of cancer, including tissue culture—The Administrative Officer, Mount Vernon Hospital, Northwood, Middlesex.

REPORTS and other PUBLICATIONS

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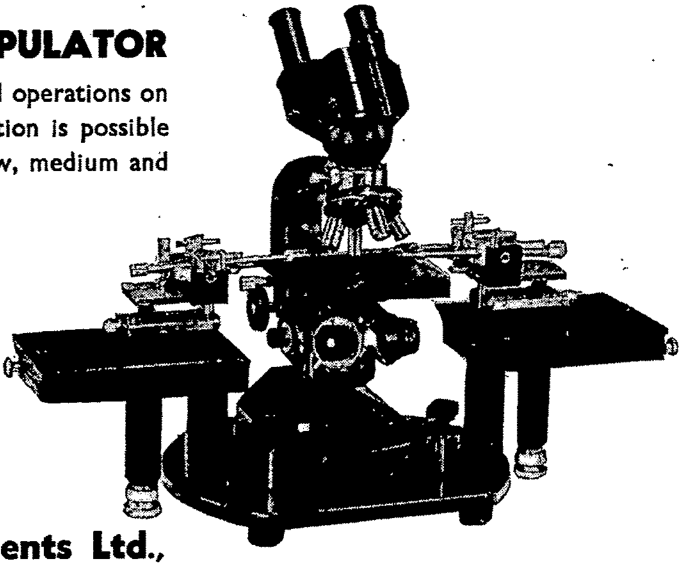

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ACADEMIC AND PROFESSIONAL MOBILITY

THE discussion on academic mobility at the Home Universities Conference last December*, the report of which was published early this year, originated in an inquiry of some members of the Association of University Teachers in 1956, which was briefly described by Dr. C. M. Rigby in opening the discussion. Out of 749 who replied, excluding assistant lecturers, 124 had had no other experience, and 50 of these had graduated in the university in which they were then teaching; 301 had had no experience of teaching in any other university, and of these 116 were graduates of the university in which they were teaching. Only 216 had experience of teaching in one other university, 81 of two other universities, and 27 of three or more other universities. While these figures relate to only about 8 per cent of the total staff of the universities of the United Kingdom, they indicate that possibly half the academic staff of these universities have taught only in a single university and 15 per cent only in the university in which they themselves graduated.

The inquiry thus suggests that university life in Britain is not being enriched by the movement of university teachers from one university to another to the extent that is desirable; indeed, during the discussion, Prof. R. O. Buchanan commented that mobility between Britain and overseas universities is easier and better provided for than mobility within the United Kingdom. He did not, however, suggest that even here the provision is adequate, and Dame Lillian Penson stressed the importance of mobility between the United Kingdom and countries overseas. She believes that we have now reached a very critical stage in the task the universities of the United Kingdom have undertaken since the War in helping to build up new universities in the Colonial and overseas territories. These territories are becoming genuinely independent and need help from Britain more than ever; but it may not be so easy to persuade people from British universities to make their careers overseas. This is partly due to the belief that their services in university institutions overseas will not be required for long, and Dame Lillian pointed out that we have not yet built up sufficiently a system for seconding experienced members of universities to these overseas universities for one or two years.

Dame Lillian's plea is fully endorsed by a relevant passage in the latest report on "The Colonial Territories, 1957–58". Commenting on this situation, Prof. Buchanan remarked on a difficulty which the Advisory Council on Scientific Policy noted in a wider context in its 1956–57 report. Pointing out that young scientists and technologists holding fellowships or studentships in the United States or Canada are discouraged from returning to Great Britain by the practice of requiring them to return for interview if they are to be considered for employment by British firms, the Advisory Council suggested that industry should set up an organization in the United States and Canada to interview graduates on behalf of United Kingdom employers. Prof. Buchanan obviously believes that such a measure would assist the return flow to Great Britain, but he points out that in actual practice the overseas Dominions and the Colonial universities and university colleges themselves get most of their staff from Britain, or from Canada, without local interviews. Instead, they rely on interviews in the country of origin of the candidates by people whose judgment they are prepared to trust. Prof. Buchanan thinks that on the whole the results are no worse than they are in Britain, where the appointing committees are interviewing committees also, and he suggested that the United Kingdom universities would do well to advertise their vacancies not only in the United Kingdom but also over the whole of the Commonwealth and in the United States, and to arrange for local interviewing committees for candidates from areas overseas. The reports of these overseas committees would then be studied in conjunction with the reports of their own interviewing committees on candidates in Britain. Prof. Buchanan recognized what is involved in this suggestion and the risks that would be incurred; but his suggestion of interviewing committees overseas was fully supported by Prof. H. C. Baldry, who was emphatic that this question of interview is at present a major obstacle—so much so that people in university posts overseas normally only move when they come to Britain on sabbatical leave. He also pointed out that the interruption of research involved in moving is serious, and can itself be an obstacle to mobility. The latter difficulty could be minimized to some extent by administrative action; but the importance of academic mobility, particularly in relation to the universities overseas, was well demonstrated in the discussion by the deep appreciation of representatives of such universities in the practical interest of the Conference.

Nor is the interest of the problem limited to the universities themselves. Academic mobility is itself one facet of that interchange of knowledge and culture which is an indispensable element in creative work, the importance of which was stressed by Sir George Thomson in his Fawley Foundation Lecture, "The Strategy of Research", last October. Apart from its contribution to good relations and understanding within and without the Commonwealth, interchange and movement contribute much to the communication of ideas and the stimulation of thought, and we would be wise to foster it as fully as possible.

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* Report of the Proceedings of the Conference of the Universities of the United Kingdom, convened by the Committee of Vice-Chancellors and Principals, and held in the William Beveridge Hall, University of London Senate House, on 13th and 14th December, 1957. Pp. 111. (London: Association of Universities of the British Commonwealth, 1958.) 5s.

That contribution was brought out incidentally by Prof. A. G. N. Fleur at an early stage in the discussion at the Home Universities Conference; but Dr. R. S. Aitken, vice-chancellor and principal of the University of Birmingham, from a study of data from Birmingham, believes that we may already have as much mobility in the science faculty as is desirable, but that in ten to twenty years time there may be an increase in stability at the expense of mobility unless the universities, in concert, extend to senior lectureships the practice of appointment from outside in preference to promotion already customary by many in connexion with chairs. This point was strongly urged by Prof. Fleur, who also suggested that the Association of University Teachers survey should be extended. We need, he thinks, more detailed information, and while undoubtedly too much mobility can lead to waste, its value in broadening the mind, stimulating experiment and reform and disrupting complacency is undeniable.

It is, of course, true, as Prof. J. L. Montrose remarked, that some of the advantages in mobility could be secured by more exchange in the universities between members of different disciplines; but there is clearly much that could be done by the universities themselves to remove existing hindrances to mobility, many of which, as Dr. Rigby pointed out, are personal or domestic. One difficulty, however, requires wider action, and that is the matter of pension schemes, mentioned by Dr. Rigby but developed more fully by Dr. B. V. Bowden, who referred to the constant interchange of staff between the Manchester College of Science and Technology and industry. This movement is encouraged by all possible means and the College seeks to replace those who leave by people from industry, regarding this as an essential part of the operation of the College. It is important, said Dr. Bowden, that people should come and go between education and industry several times during their professional life, but such interchange is often rendered very difficult by inflexible pension schemes. Representations have been made through the Institute of Actuaries, the University Grants Committee and the Federation of British Industries to try to get something done in the Millard-Tucker Committee, but income tax law makes it extremely difficult for pension schemes to be made portable, particularly in a time of inflation.

Dr. Bowden suggested that the problem deserves much more serious study than it has yet received; but it is also clear that here is one of the points at which Government action could be decisive. Dr. Bowden's remarks also indicated the bearing of academic mobility on the expansion of higher technological education and on education policy generally. He referred specifically to the value of movement not simply between the universities and the colleges of technology and industry but also between the universities and the schools. Factors which hinder movement between the universities and industry can equally hinder the movement between the universities and the schools, and if only for its bearing on the shortage of science teachers, the problem is one that demands the attention of Government in its approach to the expansion of university, technological and technical education.

Academic mobility should not be regarded, in fact, as simply a matter of movement between the universities in the United Kingdom and overseas. It should be considered rather as a matter of promoting the movement of trained men and women, so that they gain the wide experience and varied stimulants they need for the full development of their professional capacity. It should include movement to and from the Government service, the research associations, the technical colleges and industry as well as between universities and the colleges of technology. Upon the care with which it is fostered depends in no small degree the most effective use of the limited resources of trained men and women, and equally the ability to increase these resources both generally and in the particular categories in which they are most urgently needed.

These questions were brought in relation to one particular type of scientific worker in a discussion arranged by the Institute of Biology, a report of which was published in the Institute's *Journal* early this year (see *Nature*, 181, 677; 1958). Dr. E. E. Weatherby's address in particular shows the importance of academic mobility for professional men in general who are seeking service overseas. The matter will require much greater attention than it has yet received before we can hope to find that sufficient numbers of professional men and women are prepared to venture overseas, not merely to serve in universities and other educational institutions but also in other spheres, including the research institutions, many of which are closely linked with the overseas universities and university colleges.

As Dr. Weatherby pointed out, in the re-organization of the Colonial Service the Government has sought to deal with the important issue of security, but only a beginning has been made and much yet remains to be done. Any action the universities may themselves take to encourage academic mobility may well have an effect far outside their walls, particularly in so far as movement to and from the overseas university institutions is concerned; but there are difficulties; notably in security and in regard to pensions, which only government action is likely to solve. Such action is desirable, and indeed imperative, if Britain is to play her full part in assisting the overseas territories to develop their resources and to build up universities and colleges, research institutes and other public services with high standards and great traditions; it is also essential to enable Britain to take a fitting part in technical assistance to the under-developed countries, either under the Colombo Plan or the United Nations. It may equally determine whether we are able to develop what has well been described as our most important and vital export to-day, namely, that of trained man-power, on which will largely depend how far we can make full use of such assets as we possess in nuclear power and like developments.

Ultimately, however, the reason for fostering the movement of trained men and women, between the universities of the United Kingdom and overseas, or between university institutions and industry, the Government service, research institutions, and other walks of life, lies in the contribution it makes to the stimulation of creative thought and the quest for new ideas. Beyond even the contribution to international understanding, this factor is all-important if mankind is to regain control over events. We cannot afford to neglect any means that promise to stimulate creative and imaginative thought, the receptivity to new ideas, sound judgment and the open mind. The expenditure required to remove some of the obstacles is trifling compared with the benefits which the nation and indeed all mankind might well reap, and it is to be hoped that the lead which has already been given will be assiduously followed up by professional associations as well as by the universities and also by such bodies as the Parliamentary and Scientific Committee. At the least, Government policy should be directed towards ensuring that, so far as administrative action can provide, the fullest freedom exists for the contact of trained minds, the communication and discussion of ideas, not only through the printed word but also in those personal contacts which the evidence of the centuries has shown to be so fruitful and stimulating.

RUMINATIONS ON RADAR

Three Steps to Victory

By Sir Robert Watson-Watt. Pp. 480+25 plates. (London: Odhams Press, Ltd., 1957.) 30*s.* net.

THIS book is a combination of an autobiography and a documentary history of the development and applications of radar, intended to clarify the part played by the author and various colleagues. After soliloquizing in an introductory chapter on the theme "Happiness is No Private Enterprise", the book starts somewhere in the seventeenth century and proceeds to beyond 1952 in a final chapter entitled "Happiness in Private Enterprise". But the progress from one end of the book to the other is by no means linear in time. It can be regarded as covering forty years of the author's life, during which the idea of radar was born, forced rapidly through a lusty boyhood, and on to a most vigorous manhood to play its outstanding part in the Second World War and after. The important events are related not in strict chronological sequence, but almost as the author reminds himself of outstanding milestones combined with what many would regard as trivial memories of irresponsible deeds or conversations. We travel backwards and forwards through this period of time in a manner which may not be disturbing to one who, like myself, has lived through the same period and in some sort of touch with the subject. Indeed, having spent almost exactly this period of forty years, oscillating in a very erratic manner between the National Physical Laboratory and the Radio Research Station, where some ten years of the action was played, I found the book of considerable interest. Whether the so-called 'plain man' for whom it is supposed to be written will do so is more questionable; and especially is it doubtful whether the reader of the future, anxious to study the history of the subject, will find it easy to secure an orderly array of the wide range of facts presented to him.

But it is time to tell the reader of this review what the book is about. In the course of seventy-six chapters, and nearly 500 pages, it presents a most attractive and detailed account of the author's reflexions on the outstanding part which radar played in determining the outcome of the Second World War; and for which he and a syndicate of colleagues associated with him received a not inconsiderable financial award. The "Three Steps to Victory" were: first, the instantaneous visual direction-finder developed for locating the sources of atmospherics and belatedly patented by the author in 1924; secondly, the demonstration of radar and its development into a military weapon that revolutionized the art and practice of war in the air, at sea and on the ground; and thirdly, the application of the technique of operational research, which brought the back-room scientist into the planning as well as into the analysis of the day-to-day operations of war.

The main theme of the book is centred around the second of the above items. After preliminary thinking and discussion, a demonstration was given on February 26, 1935, by A. F. Wilkins—the author's closest and most active colleague in all the early work—of the possibility of detecting aircraft by reflexion of radio waves. This experiment was, however, merely to confirm the sound basis of a memorandum entitled "Detection and Location of Aircraft by Radio Methods" which was considered on the following day (February 27, 1935) by the British Committee for the Scientific Survey of Air Defence. This memorandum, which is reproduced as an appendix to the book, is regarded by the author "as marking the birth of radar and as being, in fact, the invention of radar". From this point, the book describes the trials, tribulations and successes which accompanied the conversion of an interesting scientific technique into a practical application, with the tools and equipment placed in the hands of, and entirely operated by, military personnel. The story is told in the author's inimitable style, generally interesting, but sometimes rather involved and not easy to follow. He is naturally reviewing the events with the advantage of his own 'hindsight', but still endeavouring to describe the foresight which was used and applied at various stages of development. Much of the story is supported by references to published and unpublished material, and also to conversations in various high official places. In some cases the speakers who may have commented either lightheartedly or in the heat of an important and urgent discussion may be surprised to find their remarks recorded in cold print.

Chapter 45, with the intriguing title "My Greatest Mistake", explains how the first step—the 'C.R.D.F.' or visual direction finder—was not applied in practice until the middle of the War on account of the pressure of other techniques, followed by the difficulty of making changes once manufacture had started. But the realization that the time of travel of a rocket (*V*2) from firing site to target would be only a few minutes soon brought the 'C.R.D.F.' set out of its 'cold storage'. Another interesting chapter entitled "Hawaiian Week-end" gives a brief account of the Japanese attack on Pearl Harbour on December 7, 1941 (not 1940 as on p. 311), and this is used to illustrate the limitation of the human element in collecting and acting upon information provided by radar. Looking back from the present time, it requires a mental effort to realize the lag of the United States behind Britain in the initial application of radar. As early as the autumn of 1937 it was clearly accepted at the highest professional level that radar was an invaluable and indispensable element in the defence of Great Britain; but four years later the corresponding value and indispensability had still not been recognized in the United States.

To some readers the book may appear to be egotistical; but it is perhaps inevitable that an autobiography must make very frequent use of the first person pronoun. I thank the author for his introduction to a number of unusual words, some of which I found defined in the dictionary; and I was interested to learn that the National Physical Laboratory is an "oddly schizoid institution". The book is a long one for the 'plain man' to read, but perhaps the author's attitude is similar to that of another author (of radio technical books) who once remarked to me: "Maybe there are twice as many words as are necessary, but the reader either gets it that way or not at all". The long text is relieved by a number of most interesting photographs of places and personalities associated with this particular story of radar.

R. L. SMITH-ROSE

NERVES AND MUSCLES

Comparative Physiology of the Nervous Control of Muscular Contraction

By Dr. Graham Hoyle. (Cambridge Monographs in Experimental Biology, No. 8.) Pp. viii+147. (Cambridge: At the University Press, 1957.) 15*s*. net.

THE science of comparative physiology may be said, broadly, to have two objectives. It attempts, on one hand, to describe in an analytical manner the normal working of the variety of animal species, and so to supply evidence, of a different kind from that derived from the study of comparative anatomy, which may help to suggest evolutionary trends. On the other, comparative physiologists attempt, by making use of the variety of physiological processes found in the animal kingdom, to discover the fundamental physico-chemical mechanisms at work in living matter, choosing their material for each investigation so as to take advantage of the peculiar advantages offered by life's variety for the elucidation of its common features.

Dr. Graham Hoyle's monograph on the "Comparative Physiology of the Nervous Control of Muscular Contraction", the eighth in the series of Cambridge Monographs in Experimental Biology, provides an excellent example of an inquiry with the second objective. The field embraced, which is the functional connexion between nerve and muscle, might seem at first sight to be a narrow one; but, as the author points out in his preface, "since a myoneural apparatus is present in all phyla except the Protozoa and the sponges, there is a wide range of animals in which to study the problems". These problems have been intensively studied in recent years in one or two animal types, and a truly comparative review of the whole animal kingdom was certainly called for.

It is taken as axiomatic that the nervous control of muscle *excitation* is an essential stage in the control of muscular *contraction*, and the greater part of the book is concerned with the process whereby the arrival of a nerve impulse at the neuromuscular junction initiates a change in the electrical potential across the surface membrane of the muscle fibre. The full analytical framework used to interpret experiments on neuromuscular physiology is set out about half-way through the book on pp. 67–68. Dr. Hoyle precedes this with one valuable chapter on comparative histology and three on the general biophysics of excitable membranes, which are necessary for an understanding of the myoneural mechanisms. He then goes systematically through the Metazoan phyla, showing how far it is possible to interpret the different mechanisms as variations on the common theme. It could be objected that the framework is derived too largely from detailed studies on the vertebrate and crustacean junctions, and that the provisional assumption that the "broad principles . . . have universal application" is a dangerous one. The immediate answer is that no other analytical framework has yet been suggested, and that it is strength rather than weakness in a hypothesis that it should be clearly stated and be amenable to verification or refutation.

In his last chapter Dr. Hoyle touches on the remaining parts of the control sequence, such as the coupling of muscular excitation to contraction, and the problem of contractility itself. He also discusses the evolution of the myoneural apparatus and mechanisms, and is left with the impression that this has been concerned almost exclusively with modifications of existing parts, the essential features of the architecture and function of the junctions either having reached a satisfactory standard at an early stage, or representing the only possible system. It is, of course, valid to discuss evolutionary trends only in a very broad context of the working of the animal as a whole, and this is only briefly attempted. Within the precise field which it covers this monograph is, however, a valuable addition to the none too plentiful literature on comparative physiology.

J. W. S. PRINGLE

MICROBES AND DRUGS

Ciba Foundation Symposium on Drug Resistance in Micro-Organisms

Mechanisms of Development. Edited by G. E. W. Wolstenholme and Cecilia M. O'Connor. Pp. xii+352. (London: J. and A. Churchill, Ltd., 1957.) 50*s*. net.

Drug Resistance of Microorganisms

By Robert J. Schnitzer and Emanuel Grunberg. Pp. xiv+395. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 10 dollars.

"CHEMOTHERAPY has still many problems to solve . . . [the greatest perhaps] is how to prevent the rapid development of resistant strains of parasites in relation to the action of specific chemotherapeutic remedies." Thus did Findlay in 1950 express the concern of those whose work is the discovery and development of such agents. Despite the importance of drug resistance and the amount of published work which has appeared, there has been, until now, no text-book available for reference or instruction. Drug resistance has been considered in many surveys of chemotherapy, but these have of necessity covered only the broadest outlines of techniques and results, and even less of the mechanisms of development. The publication of both these books is therefore timely.

It is a disquieting admission that chemotherapy is still, after more than half a century of vigorous life, essentially an empirical science. This fact is probably a constant source of intellectual discouragement to the chemist who may be successful in his search for an effective chemotherapeutic agent but who at the same time has little or no idea of the mode of action of that agent. Such success may also bear little or no relation to the thought that has gone into his research. A further source of discouragement may be the emergence of resistance to an otherwise excellent drug. It is generally felt that the answer to this problem can be found only by biochemists and microbiologists.

For this reason, therefore, the Ciba Symposium on Drug Resistance in Micro-Organisms (Mechanisms of Development) was arranged with participants from America, Europe and the U.S.S.R. The first book under review is the result of this Symposium and contains, as is usual in the Ciba Symposia reports, both original papers and ensuing discussion. The papers, representing the efforts and views of leading workers in this field, cover a very wide range of subjects from the general—Dean and Hinshelwood's "Aspects of the Problem of Drug Resistance in Bacteria" and Demerec's "Genetic Aspects of Drug Resistance"—to the particular—Alexander, Cousens and Stacey's "Reactions of the Mutagenic Alkylating Agents with Proteins and Nucleic Acids". It is invidious, however, to select individual papers—there are eighteen altogether—since the standard is uniformly high and the ensuing discussion controversial and stimulating. There is an understandable tendency, however, to concentrate on the academic rather than the practical aspects throughout; understandable since so little work has been done in the field to deal with the problem of resistance. This is gently pointed out in the final general discussion by Lederberg, whose remarks constitute a crystallization of the more practical issues. The main value of the Symposium seemed to be a reconciliation between the two main schools of thought as to the prime responsibility of genetic mutation rather than phenotypic adaptation for resultant resistance.

The second book is an encyclopædic work on the experimental approach to the study of drug resistance. After a brief but valuable appraisal of the history and various aspects of drug resistance, the authors exhaustively set out the methods used for the production of resistant strains of protozoa, spirochætes and bacteria, and discuss the properties of such strains.

The third and longest section of the book is devoted to mechanisms of resistance with particular emphasis on specificity and cross-resistance. There can be no doubt that a considerable amount of information can be obtained about the mechanism of antimicrobial action of substances from a study of specificity and cross-resistance, and this is well brought out here. Further evidence can be obtained from studies on drug antagonism and synergy; these aspects are also discussed. The brief section on theories of drug resistance describes some of the general hypotheses now in vogue and makes stimulating and thought-provoking reading. This is a book which should be on the desk of every worker in the field of chemotherapy.

I. M. ROLLO

MEDICAL STATISTICS

Manual of the International Statistical Classification of Diseases, Injuries and Causes of Death

Based on the Recommendations of the Seventh Revision Conference, 1955, and adopted by the Ninth Health Assembly under the WHO Nomenclature Regulations. Vol. 1. Pp. xli+394. Vol. 2: Alphabetical Index. Pp. xxvi + 540. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 35*s*. (2 volumes).

CLASSIFICATION, which is fundamental to the quantitative study of any phenomenon, has presented particular difficulties when applied to the study of illness and death. A statistical classification of disease must be of manageable proportions; it must be arranged in such a way that the important disease processes can be examined numerically; it must be designed so that every condition will find a place somewhere; and it must restrict entries to conditions of importance by reason of their frequency or gravity. It differs, therefore, from a medical nomenclature, which should provide a catalogue of terms both detailed and extensive, with an encyclopædic quality which must hinder rather than aid statistical calculation.

But perhaps the greatest difficulty in classifying disease lies in the absence of any unifying system. Any classification is inevitably a compromise between a number of conflicting points of view, of differences of opinion as to etiology, anatomy, clinical features, age, etc. Thus no systematic classification of disease is practicable.

"The medical practitioner may found his main divisions of diseases on their treatment as medical or surgical; the pathologist, on the nature of the morbid action or product; the anatomist or the physiologist on the tissues and organs involved; the medical jurist on the suddenness or the slowness of death; and all these points will deserve attention in a statistical classification." (William Farr.)

Even this does not end nosological difficulties. The classification must also have regard to the variations in medical terminology—as between medical men of different vintage or varying specialities or countries. The neoplasms in Britain and elsewhere are varyingly named according to the view as to the pathological process involved; anthrax in French-speaking countries is a staphylococcal infection of the skin and in English, German and other languages it denotes an infection by *Bacillus anthracis*. So many varieties of clinical description of mental disorders are in use in different countries that no one classification could completely satisfy everyone.

Classification of disease must also be bound by expediency—seeking to fit diseases into a framework which aids comparative measurements. Thus influenza and pneumonia are grouped under diseases of the respiratory system and not under infective diseases, mainly because of their close association with acute upper respiratory infections, so many of which are of unknown etiology. Rheumatic fever, for a like reason, has recently been classified with diseases of the circulatory system—because of the cardiovascular sequelæ of the disease—although as a disease of connective tissue it might stand on its own. Degenerative vascular changes manifest themselves as hypertension, arteriosclerosis, cardiac and renal affections or lesions of the central nervous system—it is mere convenience to include cerebral hæmorrhage under diseases of the nervous system; chronic nephritis under diseases of the genito-urinary system; and hypertension under diseases of the circulatory system —although the pathological processes in the body may not be greatly dissimilar.

It follows from these illustrations of the difficulties to be found in classifying disease not only that international agreement can have been achieved only after long discussion, but also that adjustments to any agreed classification will be made with circumspection and must wait upon advances in medical knowledge which have general acceptance.

The outstanding event in a hundred years of international deliberations on the classification of diseases, injuries and causes of death must be accounted the Sixth Revision which appeared in 1948. This was not only the first with anything like world-wide acceptance, but also it provided the first statistical classification for both morbidity and mortality. The Seventh Revision of the International Lists of Diseases and Causes of Death, resulting from the international conference held in Paris under the auspices of the World Health Organization (February 21–26, 1955), which appears in two volumes (classification and index), has made little change in the 1948 manual. The classification is arranged somewhat eclectically in seventeen main sections: the first consists of well-defined infective agents; then follow categories for neoplasms, allergic, endocrine, metabolic and nutritional diseases, with the remaining diseases classified according to their principal anatomical site—nervous, circulatory, respiratory, digestive, genito-urinary systems, the skin, the bones, and congenital malformations. There are special sections for mental diseases, complications of pregnancy and childbirth, certain diseases of early infancy, senility, etc., and accidents, poisoning and violence. The detailed list (pp. 1–42) consists of 612 categories of diseases and morbid conditions, numbered on a decimal system with three-digit numbers. The first two digits present summarily important groups that are significant, and the third digit represents specific disease entities. Thus under deliveries and complications of pregnancy, childbirth and the puerperium (represented by 640–689) complications of pregnancy begin with the digits 64 and those of the puerperium with 68—nine disease entities under each heading being further represented by a third digit. The tabular list of inclusions (pp. 45–353) gives the framework of the classification and lists the conditions included in each category of the detailed list.

The first volume also includes an account of the international agreement on medical certification and the rules for classification. This is in itself as important as the classification, since it greatly affects the validity of certification and the comparability of results.

The introduction to Volume 1 provides a readable, if rather too brief, account of events leading up to the present position and the particular steps which the World Health Organization is now taking to improve the validity of statistics dealing with sickness and death, including the Expert Committee on Health Statistics, National Committees on Vital and Health Statistics, and the World Health Organization Centre for Classification of Diseases. For more detailed information the reader is referred to other publications in a list of references. These also might be strengthened by reference to other documents. Otherwise the World Health Organization has produced an unexceptionable work of great significance to the measurement of health.

CONTROL AND COMPULSION

Economic Planning by Programme and Control in Great Britain

By Prof. Gilbert Walker. Pp. xii+175 (4 plates). (London: William Heinemann, Ltd., 1957.) 18*s*. net.

PROF. GILBERT WALKER brings together in remarkably small compass the main features of government planning and control in Great Britain during the Second World War and the years immediately following it. The early chapters, comprising about one-third of the book, trace the development of economic thought on the problem of unemployment and poverty, explain the use of social accounts as a tool in making policy decisions, and describe the operation of controls in the mobilization of resources during the War. The remainder of the book is concerned with the planning techniques designed to aid a smooth transition from war-time to peace-time conditions and to avoid the boom and slump which followed the First World War.

An inevitable result of trying to cover such a wide field is that the treatment of certain topics suffers from too much compression. For example, the casual reader of Chapter 2 might conclude that the consequence of an increase in income will be the same whether it arises from increased wage-rates or from increased production. Similarly much benefit would be derived from a short section reviewing the changes which occurred in Britain's position as a result of the War and made the continuance of controls necessary.

The author's assessment of the desirability of economic planning emerges towards the end of the book. Government control is practicable in war-time. But in peace-time:

"Democratic governments, determined to remain within the letter and the spirit of the Western tradition, but bent nevertheless on assuming a deliberate and positive control over the direction and magnitude of economic change, have to find the means, other than compulsion, of ensuring that citizens, obeying whatever impulses may move them, freely choose the courses which correspond to the employment of resources marked out by the planners."

The antithesis between Western tradition and compulsion is a false one. Western democracies have long used compulsion in ordering economic life. That a considerable amount of planning was carried out after the War without active compulsion says a great deal for the flexibility of the plans and the good sense of those responsible for their execution. Powers of compulsion, however, existed and although unused they may well have contributed to the success of the Government's economic policy.

Prof. Walker's publishers state that he has written this work with the object of interesting the wider public; many professional economists also will find most useful and enlightening its descriptions of the mechanism of controls and its assessment of their effectiveness.

NORMAN CUTHBERT

THE RAT

Anatomy of the Rat

By Eunice Chace Greene. (Originally published in 1935 as Volume 27 (New Series) of the Transactions of the American Philosophical Society.) Pp. xi+370 (339 figures). (New York and London: Hafner Publishing Company, 1955.) 25 dollars; £9.

The Genesis of the Rat Skeleton

A Laboratory Atlas. By Donald G. Walker and Zolton T. Wirtschafter. Pp. vi+59 (53 plates). (Springfield, Ill.: Charles C. Thomas; Oxford: Blackwell Scientific Publications, 1957.) 57*s*. 6*d*.

THE "Anatomy of the Rat", by Mrs. E. C. Greene, is essentially an atlas and a text-book in quarto form. The text and illustrations occupy about the same space. When this book appeared in 1935 it provided the most complete account of the anatomy of the rat and was a most valuable supplement to the second edition (1924) of H. H. Donaldson's "The Rat". The latter was a mine of quantitative information, presented in tabular and graphic form, for the weights and dimensions of various parts of the body from birth to maturity. In fact, Donaldson presented more pertinent and accurate data on the rat than was available elsewhere for man. His bibliography extended to about 2,000 references. Since then the number of references has more than doubled, for the Wistar rat was adopted as the favourite child of the experimental psychologists. The rat, particularly the Wistar and the Evans–Long strains, knew on which side his bread was buttered.

"Anatomy of the Rat", long out of print, has been reprinted and is now priced at 25 dollars as compared with 5 dollars in 1935. The minor blemishes of the first edition persist; the usual failure to appreciate the genetive form of Latin and Greek words is as before. The removal of these minor blemishes and a few errors of fact may be looked for when a new edition of the book appears. The only weakness in this best of books is the lack of detailed information on the brain, which has assumed great importance as a result of the work of experimental neurologists such as Lashley in Chicago.

"The Genesis of the Rat Skeleton", by Walker and Wirtschafter, of the University of Oregon Medical School, is an attempt to depict the orderly progression of appearance of centres of ossification by radiographs and photographs of alizarin-stained specimens. Little has been added to the data presented by Donaldson in his second edition of "The Rat" (1924), by R. M. Strong (1925) and by A. B. Dawson (1925–34).

This atlas measures 18 in. × 12½ in. and presents an elegant format and Hollywood calligraphy which is tiring to the eyes, especially for such new words as "Cor*o*coid" and "stern*a*bræ". The radiographs and photographs are not satisfying. Radiographs will not stand photographic enlargement to more than three diameters, as the appearance of the emulsion grain obscures the details of the bony structure.

The portrayal and labelling of the centres of ossification in the skull are inadequate. A prior knowledge of the chondrocranium is essential in order to see how the bony centres arrange themselves in relation to the issuing cranial nerves which maintain a foramen between two or three bony anlage in the skull base. Likewise, the membrane bones appear precociously as two-dimensional unilaminar sheets to guarantee the two-dimensional distribution of the overlying nerves. The absence of any anatomical text is a serious objection to this atlas, for an atlas calls for a system.

H. A. HARRIS

THE HAWFINCH

The Hawfinch

By Guy Mountfort. (The New Naturalist.) Pp. xii+176+8 plates. (London: William Collins, Sons and Co., Ltd., 1957.) 18*s*. net.

VERY much can be learnt by concentrating on a single species of bird and studying every aspect of its life, and in Britain there have recently been several admirable monographs giving the results of such work; of these, the present volume is a fine example. Although an enterprising all-round ornithologist with much else to his credit, the author has for long had a particular enthusiasm for the hawfinch. This has been the more repaying in that the species is one of the least familiar of our not uncommon birds—partly because of its wary and elusive habits, and partly because of its very local and rather erratic distribution. Many years of close observation have now enabled Mountfort to present a fascinating picture.

The hawfinch is notable for its large bill, allied with a massive skull and powerful jaw muscles. This arrangement is related to the habit of cracking cherry stones and olive kernels, a feat which the author's collaborators have shown to involve crushing loads ranging from 60 to 159 lb.—and this in a bird weighing a couple of ounces! It is also a strong flier, capable of an almost vertical take-off and of bursts of speed approaching 40 m.p.h.; the wing area is small relatively to weight, and the beats are rapid.

The species succeeds in combining richly coloured plumage, in both sexes, with a perfected habit of stealthy self-effacement. Yet in its own winter flocks and towards other species it is notably aggressive: one of Eric Hosking's photographs, which are among the illustrations, shows a bird leaping forward with snapping bill to put a much larger mistle-thrush to flight. There is also an elaborate courtship ritual, comprising a number of characteristic attitudes—fluffing of throat feathers, a 'penguin' walk, a deep bow of appeasement, an approach with dragging wing-tips, and a bill-touching ceremony. Also described in detail are the various phases of the nesting season, the song and call notes, the diet and feeding habits, together with distribution and migratory movements in Britain and elsewhere. An appendix by John Barlee deals with the flight.

It is unfortunate that, owing to publication costs, a bibliography of 650 titles could only be deposited.

LANDSBOROUGH THOMSON

Population Redistribution and Economic Growth, United States, 1870–1950

1: Methodological Considerations and Reference Tables. By Everett S. Lee, Ann Ratner Miller, Carol P. Brainerd, and Richard A. Easterlin. Prepared under the direction of Simon Kuznets and Dorothy Swaine Thomas. (Memoirs of the American Philosophical Society, Vol. 45.) Pp. xx+760. (Philadelphia: American Philosophical Society, 1957.) 5 dollars.

THIS massive collection of data forms the first part of a larger study to be prepared under the direction of Profs. Kuznets and Thomas. As the title indicates, its primary function is methodological, and the provision of the basic data. Analysis and theoretical evaluation will have to await the appearance of the second volume in the series. Well over half the present volume consists of reference tables, and there is an explanatory text which shows in detail how the tables have been computed.

The tables treat four principal topics. For each of the 48 States and for the District of Columbia there are comparable series from 1870 to 1950 giving estimates of internal migration, figures relating to the labour force, estimates of manufacturing activity and State income estimates. The amount of detailed statistical work that has gone into the preparation of these figures must have been enormous, and there is no doubt that these tables will form a most important work of reference for anyone working on the history of the American economy. In addition to the topics mentioned, there are figures relating to the rural and urban population of each State, to the agricultural and non-agricultural labour force, the number of manufacturing establishments, total wage bill of employees, income per head in various categories and so on. The limitations of the basic data and the assumptions that have been made in constructing them are fully set out. The editors and authors must be congratulated on their industry and ingenuity, and the publishers on the technical excellence of the presentation.

Collecting, Preserving and Studying Insects

By Harold Oldroyd. Pp. 327+15 plates. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 25*s*. net.

ENTOMOLOGISTS need a work bringing together techniques of collecting and preserving insects, and this book will fully satisfy them. Collecting should not be an end in itself, but a means of getting to know insects, the first step towards studying their lives and activities. As the applied entomologist knows too well, our knowledge is still pitifully small, and it is to be hoped that this book will succeed in one of its objects, the stimulation of more voyages of discovery.

Its first chapter, "Where to Look", is followed by an account of the important business of first catching your insect, describing the various types of net, light traps and other devices, and there is a section on rearing and breeding. Methods of killing, temporary preservation, and preparation of permanent mounts are explained, together with the examination of specimens, the use and care of microscopes and the photography of live as well as dead insects.

There is a section on identification, a key to the orders of insects, and a general account of the features of each order with appropriate collecting and preservation methods. Also included are chapters on classification and nomenclature, the preparation of papers and illustrations for publication, with a guide to the specialist books and journals. Useful appendixes include a glossary of technical terms, reagents and formulæ and addresses of suppliers. A practical book, well illustrated, simply written and most readable, yet detailed enough to make a permanent work of reference, it will be invaluable alike to beginners and all entomology departments B. D. MORETON

Fruit and Vegetable Preservation Industry in India

(Proceedings of the Symposium held at the C.F.T.R.I., Mysore, on 4th and 5th October 1954.) Pp. xiv+485. (Mysore: Central Food Technological Research Institute, 1956.) Rs. 6; 15*s*.; 2.50 dollars.

THIS book contains a foreword by the Director of the Institute, a list of participants in the symposium, the opening speeches and some 64 papers arranged in eleven sections (covering such varied subjects as raw materials, scientific aspects of preservation, quality control, microbiological problems, additives and preservatives, nutritive value, application of refrigeration, types of containers, plant and equipment, technical information services, etc.). It also reports the final discussion on need for action by the Government in promoting research, the type of research station required and the part the Government should play in establishing factories, together with the recommendations for fostering the industry submitted by the symposium to the Planning Commission and other Government departments.

Few, if any, of the papers contain any original data or observations but some are very useful summaries of existing knowledge. Taken altogether they provide a thorough survey of the state of the development of the fruit and vegetable preservation industry of India, and problems which will have to be faced in its further development. R. G. TOMKINS

Physics for Science and Engineering

By Robert L. Weber, Marsh W. White and Kenneth V. Manning. Pp. vii+617. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 60*s*.

IN this very sound introduction to physics, the first eighteen chapters (roughly one-third of the whole book) deal with the important background work of mechanics and the mechanical behaviour of materials, while about the same space is allotted to electricity and magnetism. The authors set out to train the reader in the methodical solution of problems, paying particular attention to units and significant figures, and set a good example in the many worked exercises in the text. Problems, indeed, make up a fair proportion of the short section on heat; while that on light is quite lavishly descriptive, with some excellent pages on spectra, a chapter on colour which is spread with coloured figures in the text, and some good photographs illustrating polarization effects. Sufficient is said about electronics and nuclear physics for the reader to grasp clearly what these subjects are about; but the really thorough spadework has gone into the two major sections of the book, which will repay an equally thorough reading. Because of the emphasis on instruction rather than description, and the type of exercise given, it is possible to place the standard fairly accurately in terms of teaching in Britain. It is about that of the Advanced level of the General Certificate of Education. G. R. NOAKES

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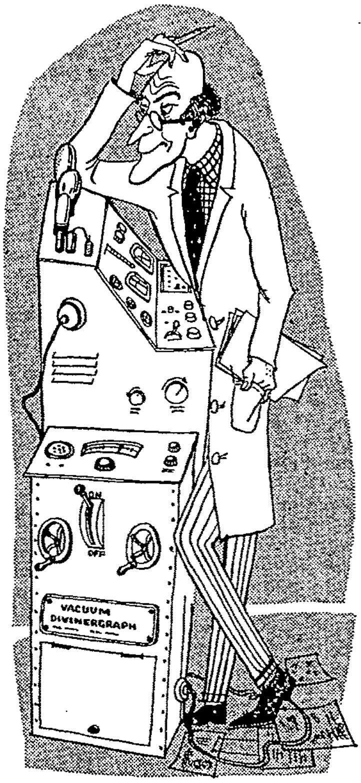

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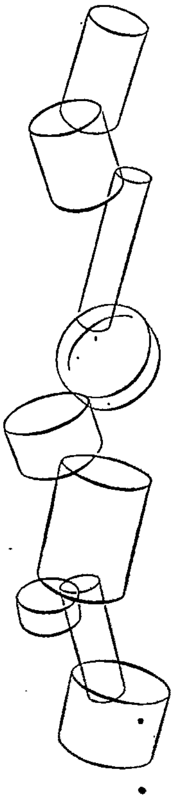

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CHEMICAL ASPECTS OF SELECTIVE TOXICITY*

By Prof. ADRIEN ALBERT

Department of Medical Chemistry, Australian National University, Canberra

SELECTIVE toxicity may be defined as the injuring of one kind of cell without injuring some other kind of cell with which the first is in intimate contact[1]. Thus, in agriculture, it is concerned with ridding crops and seeds of noxious insects and fungi, without causing harm to the higher plants. In veterinary and human medicine it is well exemplified by chemotherapy, which safely rids the host of internal parasites. A more delicate form of selective toxicity is met in pharmacodynamics. Here both types of cell are in the one species, and the task of selective toxicity becomes more difficult. This difficulty is intensified by the necessity of exerting a graded response, and of allowing the cells to recover in the course of time. Thus a patient with insomnia can be put to sleep by a drug which acts on the central nervous system, but the nerve cells which have been poisoned (and poisoned to a predetermined degree) must recover in time for the patient to go to his work next morning.

That selectivity is possible seems to rest on two main principles : (*a*) different kinds of cells exhibit very different kinds of distribution phenomena, and (*b*) the anabolic processes of different cells differ widely (catabolic processes appear rather similar). Whereas detailed knowledge of anabolic differences awaits further work in the field of comparative biochemistry, much is already known about differences in distribution.

When a substance is administered, it has to penetrate at least one semi-permeable membrane before it enters into circulation. Sometimes the substance, as administered, is only a 'pro-drug' which has to be broken down to give the true drug. Examples of this kind are phenacetin, chloral hydrate, pentavalent arsenicals and two of the antimalarials : pamaquin and proguanil. But this seems to be a rare phenomenon, and it appears that most substances act in the form in which they are given.

The circulating drug (and by 'drug' is meant any biologically active substance) then takes part in five other phenomena, to various degrees depending on its nature and on the nature of the cell[2]. It can be stored, excreted, or chemically destroyed ; it can penetrate another semi-permeable membrane, or combine with its receptor. Storage can be useful, as with the antimalarial mepacrine, which is stored in capillaries from which it is released (under mass action conditions) to maintain a therapeutic level in the bloodstream. Examples are also known where storage is wasteful or the drug is entirely segregated on 'sites of loss'[3]. Chemical destruction (detoxication), usually by primitive (not highly specific) enzymes in microsomes[4], takes place by one of seven or eight standard chemical reactions which increase partition coefficients in favour of water so that the penetration of further membranes is diminished. Excretion is usually by the kidney or bile duct in mammals, and these are so constituted that the chemical changes brought about by detoxication greatly increase the excretability of the drug[5].

If, as seems usually to be necessary, the drug has to penetrate yet other semi-permeable membranes before its meets the receptor, the chances of selective toxicity are heightened. Four different types of membranes are distinguished[6,2] : (*a*) where diffusion is regulated by pore-size, (*b*) where a lipoidal layer causes substances to diffuse at a rate proportional to their lipoid/water partition coefficient and excludes the majority of ions, (*c*) where a lipoid anion (for example, oleate) assists the passage of cations, and (*d*) where specific nutrients, particularly anions, are transported (often enzymatically), utilizing energy obtained from the simultaneous oxidation of (for example) glucose. Mixed types of membrane have also been found.

Bearing in mind the various types of membrane made available by different kinds of cells, and the various rates at which a drug, imprisoned within any pair of these membranes, will be subjected to the processes of storage, destruction and excretion, it is easy to see how specificity can be promoted merely by small changes in the rate or equilibrium constants governing any of these processes. To be added to these factors, which in sum govern the rate at which the drug will reach the receptor, is the affinity which the drug has for the receptor.

Receptors, according to Ehrlich[7], are chemical groups containing, perhaps, less than a dozen atoms, which normally perform one of the metabolic duties of the cell : when blocked by the drug they can no longer function and thus the pharmacological effect occurs. At the present time workers tend to equate 'receptor' with the active group of an enzyme.

The combination between drug and receptor seems usually to occur by secondary valencies, namely, hydrogen bonds, ionic bonds and multiple van der Waals bonds. Covalent bonds must be rare because such bonds are seldom easily broken at 20°–37° C., whereas most drug-receptor effects can be terminated by washing with saline. Ehrlich was aware of this distinction when he wrote[8] : "If alkaloids, aromatic amines, antipyretics or aniline dyes be introduced into the animal body, it is a very easy matter, by means of water, alcohol or acetone, to remove all these substances quickly and easily from the tissues". This was in 1898, before knowledge of bond-strengths, -types and -distances became as exact as it is to-day[9].

Nevertheless, a few examples are known of the formation of covalent bonds with receptors, mainly by those drugs which can acylate or alkylate (penicillin, the nitrogen-mustards and the phosphorus anti-cholinesterases), but also by a few substances which become chemically incorporated into vital parts of the cell (for example, *p*-aminosalicylic acid into folic acid, and azaguanine into nucleic acid).

Physiological action is highly dependent upon the finest details of chemical structure. If these details are varied ever so slightly, the degree of action is usually radically changed. For example, both the C-methyl-groups in thiamine are essential for its vitamin action. In synthetic drugs, a similar dependence on minute detail is observed. Thus in benzenesulphonamide (I), an amino-group can be inserted in three different positions : in two of these it gives rise to an inactive substance, but in the other it gives the highly antibacterial substance sulphanilamide[10]. Again, in acridine (II), an amino-group can be inserted in five different positions : in three of these it gives aminoacidines which are almost inert, but in either of the other two it gives a powerful antibacterial[11]. Once again, in quinoline (III), a hydroxy-group can be inserted in seven different positions : in six of these, completely inert substances are created, but in the remaining position a strong antibacterial and antifungal substance is produced.

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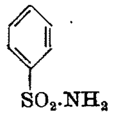
* Based on a University of London Special Lecture in Pharmacology, given in the London Hospital Medical School on June 9.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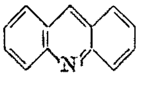
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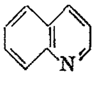
(III)

In each of these three examples, it is known why the active isomers are active, and why they alone are the active ones. The activity of the sulphonamides depends on the *para*-isomer being a metabolite analogue for *p*-aminobenzoic acid, to which it shows a close structural resemblance[10]. The activity of the acridines depends upon something quite different : only in the 2- and 5- positions can an amino-group acquire enough resonance stabilization in the cation to produce a highly ionized substance (the antibacterial action of the acridines depends on a high degree of ionization, see below). The activity of the quinolines depends on yet another principle : only in the 8-position can a hydroxy-group collaborate with the ring-nitrogen atom to bind metal cations by that pincers-like process known as chelation, and the antibacterial action of 8-hydroxyquinoline depends upon chelation[12,13].

Since the discovery of the mode of action of sulphonamides, metabolite analogues have received closer investigation and have led to the discovery of many substances which block specific enzymes and hence are of great value to the biochemist. Anti-vitamins, of similar nature, have contributed usefully to nutritional studies[14]. But in human medicine the most successful antimetabolites are, so far, all connected with pteroylglutamic acid (folic acid). This acid, a vitamin or vitamin-precursor, consists of a pteridine nucleus to which are linked *p*-aminobenzoic acid and glutamic acid. Sulphonamides exert their antibacterial action by preventing the incorporation of *p*-aminobenzoic acid into this substance, whereas *p*-aminosalicylic acid actually becomes incorporated in its place. Some antileukæmic agents of clinical value have been made by substituting amino for hydroxyl in the pteridine ring, and a much used antimalarial (pyrimethamine or 'Daraprim') was evolved as a metabolite analogue of the pteridine portion of folic acid[15]. A new type of synergism has been devised, known as sequential blocking, where metabolite analogues of two stages of the folic acid cycle are used together.

The great success of these various anti-folic acid drugs depends on a singular set of coincidences : man does not require *p*-aminobenzoic acid but must absorb folic acid from his diet, and pathogens require *p*-aminobenzoic acid to form their own folic acid, but cannot absorb it if supplied (it is possible, of course, that their folic acid is slightly different from ours). In searching for useful analogues of other metabolites, these facts have to be borne in mind.

The majority of biologically active substances are capable of ionizing to different degrees at different *p*H values ; also the extent of their ionization can be controlled by small alterations in the chemical structure. This variability in ionization is important because an ion and its corresponding neutral molecule undergo different chemical reactions, penetrate membranes differently, and become adsorbed on different types of substance[16]. Because the combination between ions and receptors must be reversible (from the very nature of the bond) the degree of ionization under the conditions of the experiment is all-important for effecting combination. This does not mean, however, that complete ionization is always an advantage, because foreign ions do not readily penetrate membranes ; also, a few examples are known where a pharmacological effect seems to be brought about by the neutral molecule[1,2].

Only two factors affect the degree of ionization of a substance : the ionization constant, and the *p*H at which the experiment is conducted. Given these, the percentage ionization can at once be read from a table[1].

The acridine antibacterials are the most studied example of positive correlation between ionization and biological activity[11]. It was shown, using 107 variously substituted acridines, that at least 50 per cent of the substance must be present as cation to give a significant bacteriostatic effect. This work produced the antibacterial substance, aminacrine, which is now included in the British Pharmacopœia.

Metal-binding substances are of two types, those like 8-hydroxyquinoline (oxine) which bind by chelation (see above), and those like dimethyldithiocarbamic acid which bind without the aid of chelation (these are usually sulphur-derivatives). Biologically, both types act similarly, provided the stability constants are high enough. Stability constants, which are derived from mass-action equations, form a reliable indication of the avidity with which a metal is held by a particular binding agent. Contrary to general belief, the various binding agents show very little differences in their preference for the different metals.

Some metal-binding agents are used in medicine as antidotes to poisoning because they withdraw toxic metals and metalloids. Examples of this kind are dimercaprol (arsenic, antimony and gold), and ethylenediamine tetracetic acid (lead). Others act by forming toxic complexes with such metals of variable valency as are present in the medium. Such a substance is oxine, which does not injure bacteria in the absence of iron[13]. Toxic complexes of this kind appear to initiate oxidative chain reactions, and death occurs very rapidly. Thus, the chelation of a metal of variable valency does not necessarily decrease its biological action, but often increases it. Measurements of oxidation-reduction potentials now in hand should give a better guide to the choice of inactivators.

Several much-used drugs, such as the salicylates, aureomycin, and isoniazide, bind metals at least as strongly as do the amino-acids, and hence could well act by chelation. Some convincing evidence concerning isoniazide has already been obtained. Chelating agents are widely used in crop-protection, for example dimethyldithiocarbamic acid and its derivates, the mode of action of which resembles that of oxine[17].

Toxicity can be brought about in other ways than through covalent bonding, metabolite analogues, ionization and metal-binding. The rupture of cell-membranes, as affected by phenols, quaternary lipophiles and polymixin, has been reviewed recently[18] and shows some selective effects.

The class of substances known as 'depressants' is unique in that the toxic effect is dependent on chemical structure only to the limited degree necessary to make the substance lipophilic enough to reach the central nervous system. Thus the inert gas, xenon, has been successfully used as a general anæsthetic in man[19]. The lack of a dipole moment indicates that this gas acts in the bulk phase rather than by adsorption at a surface. Thus it seems to be merely a diluent separating biochemical components which should react together. The mode of action of all volatile anæsthetics is almost certainly the same as that of xenon, because they all act at those concentrations which produce a standard thermodynamic activity. This was first demonstrated by Ferguson[20], and the anæsthetic activity of xenon was predicted from Ferguson's principle[21], and verified.

This presentation of the phenomena of selective toxicity has necessarily been from the chemical angle. It is put forward in the hope of supplying biologists with a framework which may help to classify results and to suggest new, and often more decisive, experiments.

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FORMATION OF A HELICAL STEROID COMPLEX

By Drs. ALEXANDER RICH* and DAVID M. BLOW*

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THE purpose of this communication is to describe the formation of a helical complex of macromolecular dimensions from the bile acid steroid, sodium deoxycholate.

The reaction was first observed when an aqueous solution of sodium deoxycholate was buffered with glycylglycine. Within a few minutes of making up a solution containing 0·1 *M* sodium deoxycholate and 0·1 *M* glycylglycine, unusual changes occur in the physical properties of the solution. There is a large increase of viscosity, and the solution can be drawn out into very long glassy fibres which are stable and dry into clear brittle rods. Soon the solution can almost be lifted clear of its container as a cohesive jelly-like aggregate. It has a mucous-like stickiness when handled. If the solution is allowed to stand, it will eventually form a clear gel which has considerable rigidity.

The complex can be formed most simply by adding acid to an aqueous solution of sodium deoxycholate. The solution becomes very viscous when the *p*H falls below about 6·8 (about 0·2 equivalent of acid). Addition of much larger amounts of acid causes a precipitate of the insoluble deoxycholic acid to form, but there is a range of *p*H and concentration in which the solution is clear and viscous. High ionic strength evidently assists the complex to remain in solution, and solutions of less than 0·01 *M* are always turbid in this *p*H range unless salt is added. The formation of the complex is immediately reversed on raising the *p*H.

By working with these dilute solutions, the phenomenon can be studied in a viscometer. In an aqueous solution containing 0·01 *M* sodium deoxycholate, 0·01 *M* glycylglycine and 0·04 *M* sodium chloride, a maximum viscosity is reached in about 15 min. The macromolecular dimensions of the complex can be demonstrated in the analytical ultracentrifuge, which shows a rapidly migrating peak with a sedimentation constant of 12–15 S. The solutions which have been described as clear always exhibit the Tyndall effect to some extent.

We should explain that we have had some difficulty in finding an adequate terminology for describing these phenomena. The above observations are characteristic of the formation of an elongated polymer. There is no reason to believe, however, that any covalent bonds are formed in this system, and so we have preferred to use the word 'complex'. Although the particles of the complex are of macromolecular size, we have avoided calling them macromolecules.

X-Ray Diffraction Studies

To study the internal structure of the complex, X-ray diffraction studies were carried out on air-dried fibres, some of which contained glycylglycine in addition to the steroid. The fibres are usually glassy clear and brittle, and have weak negative birefringence (– 0·002). The diffraction patterns are unusually detailed. Two characteristic types of diffraction pattern are reproduced in Figs. 1 and 2. Fig. 1 was obtained from a fibre with a glycylglycine : deoxycholate mole ratio of 0·5 : 1. It can be seen that the more intense layer lines are clearly resolved into a series of spots. Heavier exposures show that the weaker lines are also made up of a series of closely spaced diffraction spots. The equatorial spacings correspond to a hexagonal lattice with $a = 39{\cdot}2$ A. The first layer line spacing is 49·2 A.

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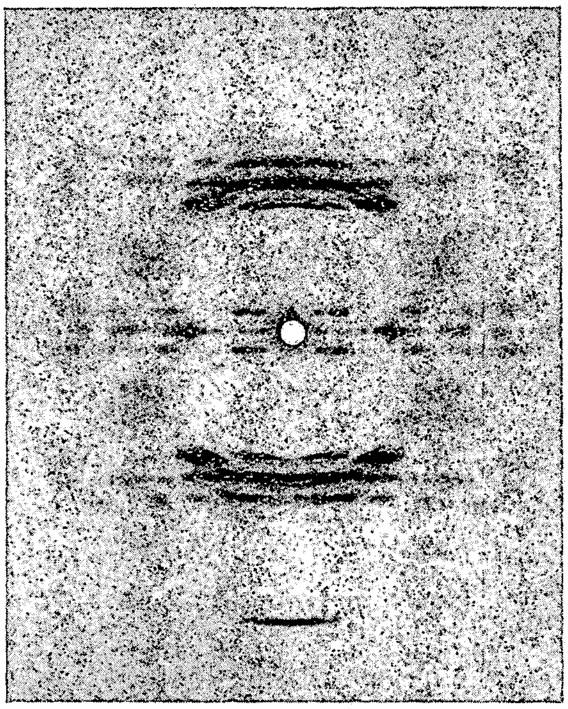

Fig. 1. X-ray diffraction photograph of sodium deoxycholate complex containing 0·5 mole glycylglycine per mole deoxycholate. Fibre axis is vertical, copper $K\alpha$ radiation

Fig. 2 shows a diffraction photograph obtained from a fibre with a glycylglycine : deoxycholate mole ratio of 3 : 1. It can be seen that the diffracted intensity still lies on a series of layer lines with an intensity distribution very similar to that seen in Fig. 1, but instead of resolved spots, a series of continuous streaks appear. This is the continuous Fourier transform and probably arises because individual diffracting units have assumed random angular orientation about the fibre axis and have also undergone some random lateral displacement. The diffraction photograph of a fibre obtained by adding hydrochloric acid to sodium deoxycholate is very similar to Fig. 1, except for changes in the lattice spacings and some intensity alterations described below. Fibre photographs have also been obtained when other amino-acids are used as buffering agents instead of glycylglycine. All these diffraction patterns show similar distributions of intensity, indicating a similar continuous transform which is sampled in different ways, corresponding to different types of crystallinity. For example, in the presence of alanine, the equatorial spacings no longer correspond to a hexagonal unit cell, but indicate another kind of packing. When there is more of the amino-acid component relative to the steroid, the continuous transform occurs more frequently and the structure is less crystalline.

Another important feature of the diffraction pattern is the occurrence of non-integral layer line spacings. Thus, the first layer line in Fig. 1 occurs at 49·2 A. The group of three intense layer lines near the meridian occurs at spacings of 7·65, 6·6 and 5·8 A. These are not integral divisors of 49·2 A. The reason for this discrepancy can be seen more clearly in Fig. 2, where the arrow points to what would normally be called the fourth layer line. It is split into two layer lines which occur at slightly different spacings. Because of this feature[1], and the open areas which occur on the meridian of the diffraction photograph, it is clear that the molecular complex has the form of a helix with a non-integral number of residues per turn[2].

In order to determine the fundamental screw operation which must be carried out to build up the helix from an asymmetric unit, it is necessary to find a true meridional reflexion which represents the translation of the asymmetric unit along the fibre axis. At first it was thought that the 6·6 A. layer line was meridional, but precession camera photographs have shown this to be less likely, and a more probable choice is the layer line which occurs at 2·29 A.

Using this interpretation of the diffraction pattern means that the 6·6 A. layer line represents the pitch of the primitive helix. Hence, we can describe the fundamental screw operation needed to generate the helix as a translation of 2·29 A. and a rotation of $\frac{2{\cdot}29}{6{\cdot}6} \times 360° = 125°$.

An air-dried fibre of the steroid helix formed by adding only hydrochloric acid has a density of 1·19 and a hexagonal a-axis of 36·2 A. (Table 1). These figures can be interpreted as indicating that there are four steroid molecules and approximately twelve water molecules in the asymmetric unit.

The diameter of the helical complex varies with the amount of glycylglycine that is added. Table 1 lists the a-axis of the hexagonal lattice for fibres drawn from solutions with varying mole ratios. Since the complex is helical, the a-axis represents the distance between neighbouring complexes and is therefore its approximate diameter. Table 1 shows

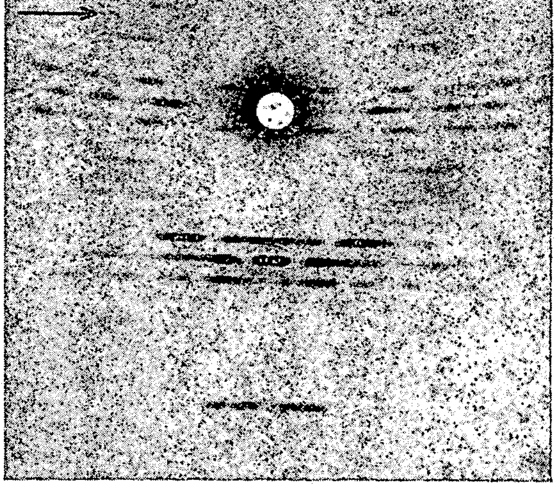

Fig. 2. Diffraction photograph of complex with mole ratio glycylglycine : sodium deoxycholate of 3 : 1. The fibre axis is vertical but tipped slightly. The arrow points to the splitting of the fourth layer line. Copper $K\alpha$ radiation

Table 1. *a*-AXIS OF HEXAGONAL LATTICE FOR COMPLEXES WITH VARYING AMOUNTS OF ADDED GLYCYLGLYCINE

Mole ratio glycylglycine : sodium deoxycholate	*a* (A.)
0 : 1	36·2
0·5 : 1	39·2
1·5 : 1	40·5
3 : 1	49·1

the composition of the solutions from which the fibres were drawn. Preliminary analyses of fibres have shown that they have the same mole ratio as the parent solutions. Addition of increasing quantities of glycylglycine causes a steady increase of the *a*-axis. The changes show that the excess glycylglycine is incorporated into the lattice. In all the diffraction photographs, the first layer line spacing remains approximately constant at 49·2 A., and the diffraction pattern does not change very much.

On comparing two diffraction patterns with differing amounts of glycylglycine, it was observed that the first layer line at 49·2 A. was more intense near the meridian in the fibre with the large amount of glycylglycine. The increase in intensity occurred at a radius $R = 0\cdot038$ reciprocal units from the meridian. In helical diffraction patterns, the relative intensity on the various layer lines is determined by the magnitude of the *n*th order Bessel functions $\sum_j J_n(2\pi r_j R)$, where r_j is the radius of the j^{th} atom, R is the radius in reciprocal space, and n is determined by a selection rule[2].

If the 2·29 A. layer line is a true meridional reflexion, the selection rule states that the first layer line is composed chiefly of third-order Bessel functions. This may be used to obtain an approximate value for the radius r of the additional glycylglycine. This is done by equating the argument of the third-order Bessel function at its first maximum to $2\pi Rr$, using $R = 0\cdot038$. The answer obtained in this way is 17·6 A. This corresponds closely to the radius of the complex and suggests that at least some of the glycylglycine is packed around the outside of the helical steroid complex. It is quite likely that this explains the occurrence of the continuous transform shown in Fig. 2, since it is more common when there is a large amount of glycylglycine. This component on the outside of the complex may hinder interactions between steroid molecules in adjacent helices and thereby reduce the crystallinity.

It is likely that in the fibres the steroid molecules are built into the helical framework, and at least part of the other component is attached to the outside. This interpretation is supported by the observation that the helical pitch of the complex is independent of the amount of glycylglycine (or of any of the other amino-acids examined). It remains to be seen whether the helical aggregate of deoxycholate molecules will surround itself with other molecules which are incorporated into the lattice as are the glycylglycine residues.

Chemical Properties

Formation of the helical complex is induced by adding protons in the form of hydrochloric acid to an aqueous solution of sodium deoxycholate. This has a considerable influence on the titration curve of deoxycholic acid (3α,12α-dihydroxycholanic acid) as compared to a closely related substance such as cholic acid (3,7α,12α-trihydroxycholanic acid). Cholic acid has a *pK* at 5·5 which corresponds to the titration of the carboxyl group located at the end of the hydrocarbon chain attached to the steroid nucleus. However, under identical conditions (0·1 *M* concentration), deoxycholic acid has a *pK* at 6·6 for the same carboxyl group. The loss of one hydroxyl group located on the steroid nucleus is inadequate to account for the large shift in the *pK* for this group. The explanation is undoubtedly associated with the formation of the helical complex in solution. The deoxycholate ion accepts a proton more readily than the cholate ion in association with its formation into a macromolecular complex. A somewhat similar example of a shift in the *pK* of an ionizable group is seen with polyadenylic acid, where the molecule can be induced to form a macromolecular helix if a proton is added to the adenine residue[3]. The *pK* of adenine has shifted by more than one *pK* unit with its organization into a helical form.

In the deoxycholate complex, it is quite possible that the added proton on the carboxyl group is used in hydrogen bonding to hold together some of the steroid residues. Whether or not all the steroid residues in the complex require a proton remains to be established.

One of the most striking features in the formation of these complexes is the enormous rise in viscosity and eventual gel formation. This must be due to the formation of helical aggregates of considerable length. A helical arrangement of sub-units is, of course, well suited to the formation of very long aggregates, as it can be elongated indefinitely. The extreme length of the particles is probably responsible for the perfection of the diffraction pattern.

A few closely related steroids have been tested to see if they would form similar helical complexes. These include sodium cholate, sodium glycocholate, sodium taurocholate, sodium lithocholate and sodium apocholate. The results were negative in all cases. The formation of the complex is thus highly specific to the geometry of the deoxycholate molecule and can be inhibited by alteration of the hydroxyl positions or by a slight modification of the steroid ring system.

Relation to the Choleic Acids

Wieland and Sorge[4] discovered in 1916 another highly specific interaction in which deoxycholic acid is involved: the formation of the choleic acids. These are crystalline solids, obtained from non-aqueous solutions, in which deoxycholic acid occurs in conjunction with a large variety of organic compounds in definite molecular proportions. The choleic acids formed with long-chain fatty acids have been closely examined and a crystallographic study of their structures was begun by Kratky and his collaborators more than twenty years ago[5]. The only other steroids known to exhibit similar properties are apocholic acid and 'β'-apocholic acid[6], compounds identical with deoxycholic acid except for an unreactive double bond in the steroid ring system.

We are thus confronted by two highly specific interactions in which the deoxycholate residue takes part. It may be helpful to summarize a few profound differences between the two kinds of interaction. The formation of choleic acids is described as an interaction between two types of compound; the complex we have described here forms alone in aqueous solution, and the primary effect is akin to a polymerization. Although the presence of other materials affects the crystallinity and the crystalline lattice of the fibre, this may be regarded as a secondary effect. Indeed, in experiments we have so far carried out, attempting to demonstrate interactions in solution between amino-acids and the complex, we have failed to find any effect. The choleic acids are usually observed in the solid state; in solution they appear only to influence the solubility. This contrasts markedly with the viscosity changes and evidence for formation of large aggregates in solutions of the deoxycholate complex. Finally, we may mention the difference in dimensions between the two. The fatty acid choleic acids crystallize in an orthorhombic unit cell, $P2_12_12$, $a = 25{\cdot}8$ A., $b = 13{\cdot}5$ A., $c = 7{\cdot}2$ A.[5]. This bears no obvious relation to the dimensions of the helix in which the complex forms.

Nevertheless, the two effects probably have some factors in common. Bernal, Crowfoot and Fankuchen[7] have noted that a hydroxyl group in the 3α position of the steroid nucleus is in a specially favourable position for hydrogen bonding. Hydrogen bonding is probably an important force in both effects, and in many other kinds of steroid interaction. What special feature of the deoxycholate molecule confers its unique properties we do not yet know.

We would like to acknowledge assistance and helpful discussion by Mr. K. Shine and Dr. D. F. Bradley, and to thank Dr. Elwood Titus for preparing a sample of apocholic acid.

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THE LAST MINUTES OF SATELLITE 1957β *(SPUTNIK 2)*

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SPUTNIK 2 made its final descent through the atmosphere between 01.50 and 02.00 hr. U.T. on April 14, 1958, on a line running between New York and the mouth of the Amazon. Though the satellite entered the Earth's shadow before reaching New York, it had by then become self-luminous and a number of valuable observations were made in the Atlantic and Caribbean from ships which happened to be near its track. Observations received from British ships are plotted in Fig. 1, together with two from Trinidad and three 'Moonwatch' observations from near New York.

For the purposes of Fig. 1, the height of the satellite was assumed to vary linearly with latitude between 70 nautical miles at 40° N. and 40 nautical miles at 10° N. This assumption is arbitrary and over-simple, but it seems to fit the facts reasonably well. If these heights were correct, the satellite, or what remained of it, would probably have come to earth just north of the equator. In Fig. 1 the estimated track of the satellite is superposed, assuming the inclination of the orbit to the equator is 65°. Estimates of the time are also given, as ringed numbers.

The appearance of the satellite became more spectacular as it proceeded farther south, and the reports from the different ships agree well, except on the question of colour. At latitude 30° N.

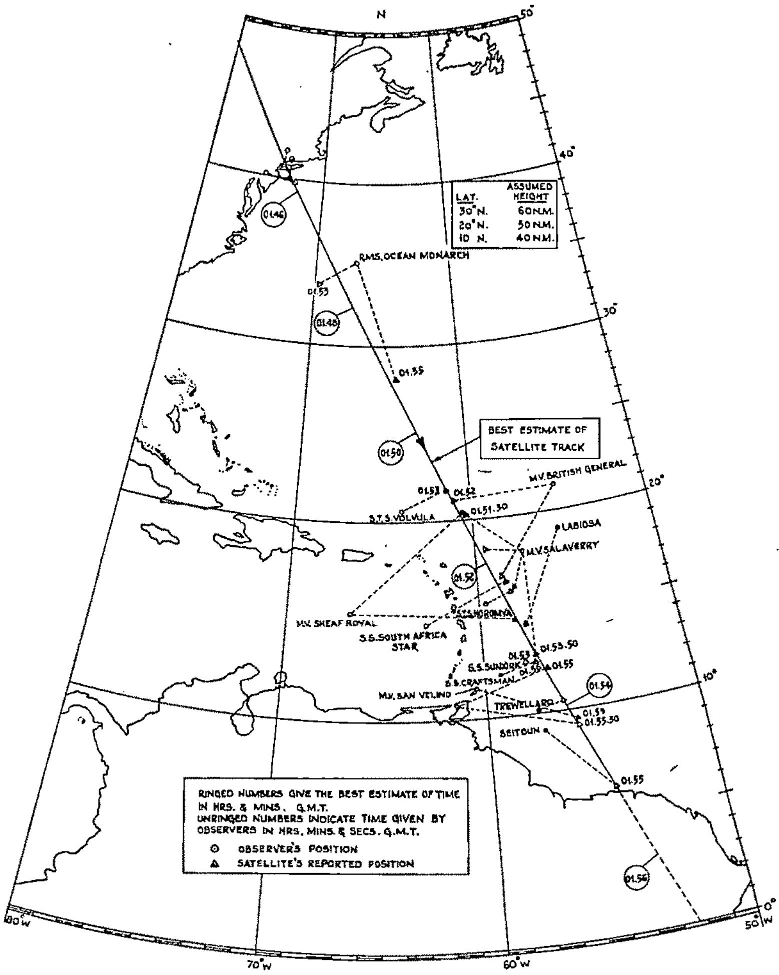

Fig. 1. The last minutes of *Sputnik* 2, April 14, 1958

the satellite was glowing a dull orange, but had developed no tail. At latitudes south of 20° N. it had a long tail alive with sparks, "like those thrown off from a grinding wheel". The sparks were often seen to fall away from the tail and then soon ceased to glow. Estimates of the length of the tail vary between 30 and 90 nautical miles, with a mean of about 50 nautical miles. The estimates of the brightness suggest that when the satellite was between latitudes 20° N. and 15° N. its stellar magnitude was roughly -5 at a distance of 100 nautical miles. The satellite seems to have taken on almost every colour of the spectrum at some time during its descent, and it is only possible to list the colours reported, which were: orange, white, yellow, greenish-blue and red; yellow and orange; orange, silver, blue and green; yellowish-white; blue and red; white to greenish-blue; red and white; green and red; red, orange and white; white; and "a rather sulky crimson".

We wish to thank the captains and crews of the ships from which observations were made. We also thank Mr. D. H. Sadler, superintendent of H.M. Nautical Almanac Office, who arranged for a general call to shipping to be made and sent us the reports received.

OBITUARIES

Dr. W. S. Bauld

THE tragic death of Dr. William St. Clair Bauld, his wife Marion, and two of their children on July 20 in a car accident in Canada profoundly shocked and saddened their many close friends in Great Britain.

Bauld was born at Wolfville, Nova Scotia, in 1919. In 1939 he graduated B.A. with honours in chemistry from Acadia University and then proceeded to Dalhousie University, where he was awarded the degree of M.Sc. in 1941 for research on the œstrogens carried out under the direction of the late Dr. R. D. H. Heard. During 1941–43 Bauld served in the Royal Canadian Artillery and was at first on the teaching staff of the Army Radar School, then becoming overseas liaison officer for the Canadian National Research Council and finally officer-in-charge of inspection of all radar equipment made in Canada. He retired from the Canadian Army with the rank of major.

After the War, Bauld decided to study medicine and enrolled at McGill University. In 1949 he graduated M.D., C.M. I first met Bauld in Montreal a year before his graduation from McGill and was greatly impressed by his personality and by his evident wish to resume research on the œstrogenic hormone. This meeting led to Bauld's appointment to a lectureship in the Department of Biochemistry in the University of Edinburgh in October 1949.

At Edinburgh, Bauld was outstandingly successful both as a teacher and as a research worker. He was a lucid and inspiring lecturer who was very popular with, and respected by, those he taught. His elegant work on the quantitative determination of œstriol, œstrone and œstradiol-17β in urine gained him international recognition as an authority in the field of the œstrogenic hormone, and in 1953 he was awarded the degree of Ph.D. for a thesis embodying the results of this work. A chance observation made by Bauld in the course of this work led to the subsequent isolation by him and me of 16-*epi*œstriol from the urine of pregnant women.

Bauld's contributions to the Edinburgh Medical School were not merely those of a first-class teacher and research worker. His capacity for working hard and playing hard and his infectious enthusiasm for everything he did acted as a tonic to all who came in contact with him. He was greatly missed when he returned to Montreal in 1954 to join the staff of the Montreal General Hospital as an assistant in the Department of Metabolism and Toxicology.

Bauld's progress after his return to Montreal was spectacular. At the time of his death, less than four years later, he had become associate director of the Department of Metabolism and Toxicology, assistant director of the Montreal General Hospital McGill University Clinic and assistant professor of medicine at McGill University, and had become recognized as a chemical pathologist of the highest rank.

The Baulds' home, whether in Edinburgh or in Montreal, was a particularly happy one where visitors were always warmly welcomed. In both cities the Baulds had many friends who loved and respected them and who will miss them sorely.

G. F. MARRIAN

Prof. G. M. Wishart

PROF. G. M. WISHART died on July 18 in his sixty-third year after a short illness. Since 1947 Wishart had devoted himself to administration, being director of postgraduate medical education and dean of the Medical Faculty of the University of Glasgow. Previously Wishart had held the Gardiner chair of physiological chemistry: the later period, given over to administration, has tended to obscure the merit of the scientific work in the earlier years.

The medical profession of to-day accepts with good grace the importance of the basic sciences in the theory and practice of medicine: it was not always so, and men such as Wishart had more than a little to do with this change of heart.

Wishart was instinctively at home in the physical sciences: his first degree was in science; he qualified afterwards in medicine. In the 1920's, biochemistry was applying accurate chemical techniques to biological problems. Wishart studied in Lund under Thunberg and this gave him an abiding interest in the factors governing enzyme action. Hydrogen ion concentration had to be measured accurately because of its importance in biological systems: Wishart designed a glass electrode to measure *p*H. He early appreciated the potentialities of the thermionic valve and designed a most sensitive electronic oscillometer to measure blood pressure in man.

About this same time the application of indirect calorimetry to man had become well established. It was now possible to measure with accuracy the factors, internal and external, influencing the expenditure of energy in human beings. Wishart made a quite exhaustive study of basal metabolism and published a series of papers with a bearing on the metabolic cost of various types of muscular work. Wishart's familiarity with the physical approach to biological problems found expression in 1931 in the publication of a most useful small book, "Groundwork of Biophysics". Yet he did not abandon his interest in more conventional biochemical studies. He took an active part in the work of the Hannah Dairy Research Institute at Ayr and spent several long vacations working in the laboratories there.

During most of this period of fruitful activity, Wishart was Grieve lecturer in physiological chemistry in Glasgow. In 1935 he was elected to the Gardiner chair, and then teaching and administration began to take their toll of his time. All Wishart's work, scientific, academic and administrative, was characterized by meticulous accuracy and by a scrupulously fair presentation of his views. No one better served his University as research worker, teacher and administrator.

R. C. Garry

NEWS and VIEWS

International Co-operation and Geophysical Research

At the recent International Geophysical Year meeting in Moscow, the following resolution was accepted: "The C.S.A.G.I. [Comité Spécial de l'Année Géophysique Internationale] endorses the A.C.I.G.Y. [Advisory Council of the International Geophysical Year] recommendation that observational and data-collecting activities in the geophysical and related sciences be conducted during 1959 on the same general plan as in 1957–58 under the direction of the C.S.A.G.I. or the C.U.R.A.G.I. [Comité d'exploitation et utilization des résultats de l'Année Géophysique Internationale] as far as practicable and at such levels and in such fields as may be determined by each participating committee. The name International Geophysical Co-operation 1959 is suggested for this period". In accordance with earlier decisions, the International Geophysical Year as such will cease at the end of 1958. It was agreed, however, that international co-operation in geophysical research shall continue in so far as each nation finds it practical, and it is left to each nation to decide in which disciplines it shall continue to make observations as during 1957–58 and whether its activity shall be on a higher or lower or at the same level as during 1957–58. The Comité d'exploitation et utilization des résultats de l'Année Géophysique Internationale is a body which will take over from the Comité Spécial de l'Année Géophysique Internationale the work of ensuring international co-operation, and in particular the utilization of the International Geophysical Year results.

California Institute of Technology: Prof. Linus Pauling, For.Mem.R.S.

The resignation of Prof. Linus Pauling as chairman of the Division of Chemistry and Chemical Engineering at the California Institute of Technology is of interest to chemists all over the world. For there can scarcely be any chemist anywhere better known than he. In his books, of which "The Nature of the Chemical Bond" will always remain a classic, and in his 300 research papers, Prof. Pauling has done more than any other person to apply the ideas of the quantum theory to the study of molecular structure. During his tenure of office, the Gates and Crellin Laboratories at 'Caltech' have achieved an almost unique reputation. It was entirely right that he should be elected a Foreign Member of the Royal Society in 1948, and receive the Nobel Prize in 1954.

True to the fate of most pioneers, Prof. Pauling has frequently been at the centre of some kind of controversy. Many people will recall the decision made in the U.S.S.R. some years ago to the effect that his theory of resonance in molecules should be rejected on political and philosophical grounds. Others will think of his difficulties in obtaining a passport from the United States, as a result of the strong opinions which he has courageously refused to disguise. But everyone will be glad that his resignation as chairman is not to imply any diminution of his research interests, for Prof. Pauling will continue in his post as professor of chemistry at 'Caltech'. During the past few years, Prof. Pauling has undertaken fundamental studies of protein structure which are of the highest importance and merit, and show promise of leading to an understanding of the molecular chemistry of such matters as mental disease. In this field his intimate knowledge of molecular geometry and crystal architecture is already showing its tremendous importance. Physicists, chemists and all those who appreciate his warm humanity will wish him well in his newly acquired freedom.

Prof. E. H. Swift

Prof. Ernest H. Swift, who is to succeed Prof. Pauling as chairman of the Division of Chemistry and Chemical Engineering at the California Institute of Technology, graduated from the University of Virginia in 1918. He joined the staff of the California Institute of Technology in 1920 and was appointed professor of analytical chemistry in 1943. As an official investigator for the U.S. Office of Scientific Research and Development during the Second World War, Prof. Swift worked on problems related to the identification of chemical warfare agents and their detection in the field. More recently he has worked on the development of coulometric analysis and is a recognized authority in this field. Prof. Swift is the author of the well-known text-books, "A System of Chemical Analysis for the Common Elements" and "Introductory Quantitative Analysis", and in 1955 he received the Fisher Award of 1,000 dollars given annually in recognition of "outstanding contributions to the science of analytical chemistry, pure or applied, in the United States or Canada".

Botany at Aberystwyth: Prof. L. Newton

Prof. Lily Newton, who is retiring from the Chair of Botany at the University College of Wales, Aberystwyth, began her career as assistant lecturer in the Botany Department, University of Bristol, and in 1920 became lecturer in botany at Birkbeck College, London, under Dame Helen Gwynne-Vaughan. She afterwards worked at the Imperial College of Science and Technology under Prof. V. H. Blackman and her special interest in algæ led her to the position of research worker in the British Museum (Natural History), where she devoted herself to the publication of a comprehensive handbook of British seaweeds. This work was continued after her marriage to Mr. W. C. F. Newton, who was cytologist at the John Innes Horticultural Institution. Following the untimely death of Mr. Newton in 1927, she became lecturer in botany at Aberystwyth and was appointed to the chair in 1930. She was president of Section K of the British Association in 1949, president of the British Phycological Society (1955–57), and while still in charge of the Department of Botany, held the offices of vice-principal and acting principal of the University College of Wales. Prof. Newton has had a distinguished career at Aberystwyth, where she continued the tradition for research on algæ established by the late Prof. Lloyd-Williams. Recently she has developed a fine botanical garden on the new College site. This will be invaluable when the new Department of Botany, which she has also planned, is completed.

Prof. P. F. Wareing

Dr. P. F. Wareing, senior lecturer in the Department of Botany of the University of Manchester, has been appointed to succeed Prof. Newton at Aberystwyth. Dr. Wareing was educated at Birkbeck College and Chelsea Polytechnic, London, while working as a Civil servant, and graduated with honours in botany in 1936. After service as a tele-communications officer during the Second World War, he was appointed assistant lecturer and later lecturer in the Department of Botany at Bedford College, London. In 1950 he moved to the University of Manchester, where he was appointed senior lecturer in 1956. Since 1947 Dr. Wareing has contributed to many important problems in the field of developmental physiology and in particular on the photo-periodic and chemical control of various growth processes. For this work he was awarded the degree of D.Sc.

Psychology at The Queen's University, Belfast: Prof. G. Seth

Dr. George Seth, who has been appointed to the newly created chair of psychology at The Queen's University, Belfast, had already built up there a small but very active Department. Its research output during the past few years has been considerable, and its graduates are already making a worth-while contribution to British psychology. Dr. Seth graduated B.Ed. from the University of Edinburgh in 1930, and thus belongs to the golden age of that degree, when Sir Godfrey Thomson and Prof. James Drever, senior, turned out year after year students who went on to distinguish themselves in education and psychology. Dr. Seth is in fact the eleventh such graduate to be appointed to a university chair. Dr. Seth went up to the University of Edinburgh from the Royal High School, and took his M.A. with honours in English literature. He remained on the staff at Edinburgh, carrying out research for the Ph.D. degree. His thesis was published in 1935 as part of the important study, "Speech in Childhood: its Development and Disorders", by George Seth and Douglas Guthrie. From Edinburgh, Dr. Seth went in 1935 to be lecturer in the Department of Education, University College, Cardiff, where he remained until 1946. In addition to his teaching work, he was psychologist in the Cardiff Child Guidance Clinic, and during 1941–45 psychologist-in-charge of the Psychological Service for Difficult Children (Government Education Scheme) under the Welsh Board of Health. In 1946 he went to take charge of the newly founded Department of Psychology at Belfast. There he has built up a well-balanced teaching and research programme, which has moved out from its beginnings in the vicinity of education to cover the whole psychological field from the experimental to the social boundaries, with applied work in the industrial and clinical as well as the educational fields. The newly created chair does no more than recognize in a fitting way the existence at Belfast of a Department of Psychology well able to hold its own with its older counterparts anywhere in Great Britain.

Control of Research Programmes in the Department of Scientific and Industrial Research

The Council for Scientific and Industrial Research has announced a change in organization affecting the Department of Scientific and Industrial Research laboratories: small steering committees are being set up to bear responsibility for the research programmes at the new Warren Spring Laboratory, at Stevenage, and at the recently renamed National Chemical Laboratory, at Teddington (*Nature*, 182, 156, 225; 1958). Formerly research boards, which the steering committees now replace, were responsible to the Research Council, but there was not necessarily any common membership. Under the new arrangement the steering committees are full committees of the Research Council and there will be a direct link between the two bodies, because the chairmen of the committees are members of the Council. In addition to the chairman there will be four members of each committee: two from industry with experience in research management, the secretary of the Department of Scientific and Industrial Research, and the director of the laboratory concerned. The industrial members of the Warren Spring Laboratory steering committee are Dr. R. Holroyd (deputy chairman of Imperial Chemical Industries, Ltd.) and Mr. D. A. Oliver (director of research of the B.S.A. Group Research Centre). The chairman is Sir Harry Jephcott, who is chairman of the Research Council and chairman of Glaxo Laboratories, Ltd. The industrial members of the National Chemical Laboratory steering committee, which will assume responsibility from October 1, will be Dr. F. Roffey (research and personnel director of the Distillers Co., Ltd.) and Mr. B. Topley (director of development of Albright and Wilson, Ltd.). The chairman will be Prof. C. E. H. Bawn, of the University of Liverpool.

Science Centre Scheme

In a written answer to Lord Bridgeman's request for a statement about the plans for a Science Centre and the reconstruction of the Patent Office, Lord Hailsham said in the House of Lords on July 30 that the Ministry of Works is negotiating for the lease of the site on the South Bank which was designated under the Science Centre scheme for the Patent Office, and it is intended to start building within the next five years. As originally proposed, this building will be designed to accommodate, in addition to the Patent Office, a new National Reference Library of Science and Invention, built up from the existing Patent Office Library. A further review of the original scheme to provide accommodation for the scientific learned societies, at present housed in Burlington House and elsewhere, on a site adjoining that which has now been leased has shown that the needs of the Royal Society and of the other scientific learned societies at present in Burlington House can, for some time to come, be met more satisfactorily in that neighbourhood. Discussions are at present proceeding between the Ministry of Works and the learned societies, and the Government has decided not to proceed with the Science Centre scheme in its original form.

Book Exports

REPLYING to a question in the House of Commons on July 28, Mr. Ian Harvey, Joint Under-Secretary of State for Foreign Affairs, said the Government was seeking to negotiate a British book export scheme with Turkey, and this was under consideration by the Turkish Government. Israel at present allocated some 500,000 dollars a year from its foreign exchange resources for the import of books and periodicals and a proportion of this was spent on imports from the United Kingdom. Indonesian imports were limited by fiscal and exchange controls, but Indonesia was able to include requests for technical books in its requirements for supplies from the United Kingdom under the Technical Co-operation Scheme of the Colombo Plan.

Baghdad Pact Nuclear Training Centre

IN a written answer to a question in the House of Commons on July 28, Commander Noble, Minister of State, stated that from the establishment of the Baghdad Pact Nuclear Training Centre in Baghdad in January 1957 to date Britain had contributed £71,722, of which £23,131 was for initial equipment and freight, £23,421 for the staff from the United Kingdom and £25,170 was towards the annual running expenses of the Centre, including the cost of certain training facilities in the United Kingdom, and of replacement and supplementary equipment.

Academic Administration

AN article in *The Economist* for July 12, entitled "Professors under Pressure", directs attention to the way in which administrative duties interfere with the teaching and research work of professors in large departments which may comprise 200–300 undergraduates, twenty or thirty academic staff and postgraduate students, twenty or more technical and office staff, an annual maintenance budget of perhaps £5,000, and a postal turnover of 4,000–5,000 items a year. The situation is likely to worsen with the increased responsibilities for dealing with new buildings—science blocks, research laboratories, lecture halls and halls of residence—which university expansion must throw on professors over the next ten years. Urging the need for fresh thinking about the organization of the university, both academic and administrative, and for a determined effort to relate the function of a university to its optimum size, and its organization to its function, the article suggests that the head of a large science department should be redesignated 'chairman' and relieved of moral responsibility for teaching and research, the title 'professor' being retained to denote scholarship and research ability.

Protection of Antarctic Fauna

THE need for measures to be taken to preserve birds in the areas of the Antarctic now being visited by man was among other subjects discussed at the Eleventh International Conference of the International Committee for Bird Preservation held in Helsinki in June last. It was agreed by the representatives of twenty countries present to urge that the question of the protection of indigenous fauna, and in particular the much threatened endemic bird fauna, be placed on the agenda of the conference on the future status of Antarctica, for which President Eisenhower and the U.S. Department of State are issuing invitations.

Age Structure in the Engineering Industry

A PRELIMINARY study of age structure in the engineering industry showed that the age of men working at a job is likely to be determined largely by difficulties inherent in the job. This investigation was conducted in the south-west of England. To support the hypothesis that the nature of the work is a major determinant of the age of those engaged in it, similar investigations have been carried out by K. F. H. Murrell and S. Grew of the Unit for Research on Employment of Older Workers, University of Bristol, in other parts of the country (*Occupational Psychology*, 32, No. 2, April, 1958). A number of firms throughout Great Britain were invited by the Institution of Works Managers to submit nominal rolls of their employees. In all, 25 firms, situated in the South Midlands, Yorkshire and Lancashire, and the London region, sent the information required. The nominal rolls included the age and occupation of each man. Although the firms which participated cannot be regarded as a random sample of firms in the engineering industry, they were sufficiently diverse in size, organization and product to be regarded as a fair cross-section of firms in the industry. In no case was the difference in mean ages of a pair of regions significant at above the 5 per cent level. This indicated that the regional samples were likely to have been drawn from the same population, and suggested that there are probably no important regional differences in the age distribution of the working population in the engineering industry. This supports the general conclusion made from the original survey.

Colonial Development Corporation

THE report and accounts of the Colonial Development Corporation for the year ended December 31, 1957 (pp. v+64. London: H.M. Stationery Office, 1958. 4*s*. net), record a net profit of £732,868, compared with £572,809 in 1956, but the net operating profit fell from £371,718 to £227,909. The fall in commodity prices had serious effects, Macalder Nyanza Mines, Ltd. (copper), showing a loss of £207,505. Four projects just coming into production or operation showed losses but should do better on full-scale working: British Honduras Fruit Co., Ltd., Kasungu Tobacco Estates, Vipya Tung Estates, and Nigeria Housing Development Society, Ltd. There are now 76 continuing projects, compared with 66, and three of the ten new projects were on the Corporation's initiative by extension of existing ones; 42 schemes were under investigation at the end of the year and gross new expenditure during the year was £7 million. Commenting on the Overseas Resources Development Act, 1958, which raises the ceiling for the Corporation's borrowing from £100 million to £150 million, the report reiterates that financing of overseas risk-bearing projects solely by repayable loan capital is unsound, and urges as from 1951 a clean start with relief from existing obligations to service capital, and cancellation of equivalent debt to Government, with a note in the accounts recording the writing off of the £8 million. A further reference to the fall in commodity prices emphasizes that this is bound to involve losses in marginal projects, such as those the Corporation necessarily undertakes, and that pressure on Colonial economies has already adversely affected projects which are not themselves primary producers.

International Council of Scientific Unions

The Year Book of the International Council of Scientific Unions of 1958 (pp. ii+74. The Hague: International Council of Scientific Unions, 1958) includes a three-page report, from the Secretary-General, for 1956–57, which records the decision to accept an offer of the Netherlands Government, through the Royal Netherlands Academy of Sciences, to provide a permanent home for the secretariat in the former Royal Palace, Noordeinde, The Hague, and transfer was commenced towards the end of the year. The proposal to publish a quarterly review containing descriptive articles of high standard and details of the current activities of the Unions has been approved by the Executive Board, which has also approved the creation of a Special Committee on Antarctic Research to consider further international organization of scientific activity in Antarctica. Active work in the field of biological abstracting has been organized and at the eighth General Assembly of the Council, to be held at Washington during September 26–October 7, the Executive Board will recommend classification of the International Geographical Union as a General Union. The Year Book is also a work of reference on the Council and the Unions, including lists of members of the Bureau, the Executive Board and the Council, joint commissions, special committees and other organs and of officers of the International Scientific Unions (together with an alphabetical list).

South African Journal of Agricultural Science

The first issue of a new journal devoted to agricultural science in South Africa has recently reached *Nature* office (*South African Journal of Agricultural Science*, 1, No. 1; March 1958. Pp. 108. Pretoria: Government Printer, 1958. 7*s*. 6*d*.). It is evidently designed to cover a wide field, and the six papers in the first issue are concerned with a fungal disease of muskmelon, a disease of citrus caused by mites, the effect on the Argentine ant of application to the soil of chlorinated hydrocarbons, the influence of lime and phosphate on the growth and uptake of blue-bitter lupin, trials of rootstocks for grapefruit, and studies on the biochemistry of cock semen. The papers are in either English or Afrikaans with bilingual titles, and the legends to figures and tables are also in both languages. The summaries are in English, Afrikaans and French. All the papers are of a high standard and the journal is well produced, with some of the plates in colour. This journal will no doubt prove of great value to agricultural scientists in South Africa as a convenient and speedy means of communicating the results of their research.

African Zoological Types

The South African Museums Association has recently published "A List of Zoological and Botanical Types preserved in Collections in Southern and East Africa" (1: Zoology, Part 1. Pp. v+147. Pretoria: South African Museums Association, 1958. Obtainable from the Director, Transvaal Museum, Pretoria. 7*s*. 6*d*.). Its title is self-explanatory: it includes all the types published in the literature up to the end of 1955 that have been traced. The total number is about 5,000, distributed among nineteen institutions and nine private collections. It is to be hoped that provision has been made for the latter to find their way into public institutions, where their accessibility and preservation can be assured. The list does not contain the types of the Karroo reptiles, as these have already been dealt with by Haughton and Brink. The arrangement of phyla, classes and orders follows that in "The Zoological Record", but for convenience in reference, families, species, subspecies and varieties have been arranged alphabetically.

Upper Atmosphere Research in the United States

In Upper Atmosphere Research Report No. 32, February 21, 1958, the U.S. Naval Research Laboratory has given a history of its rocket research programme since 1946 (pp. ii+47. Washington, D.C.: Naval Research Laboratory, 1958. Distributed by U.S. Department of Commerce, Office of Technical Services). Some idea of the extent and scope of the work is indicated by a list of more than 300 publications from the Naval Research Laboratory during this period. The report is a summary of the work carried out and the data obtained from 104 rocket flights. In addition to the scientific data obtained, the instrumentation developed has found application to problems other than upper atmosphere research. Measurements have been made involving the atmosphere, ionosphere, solar and stellar radiation, cosmic rays, air-glow of the night sky, and the Earth's magnetic field. The results achieved are impressive in quality and quantity, although measurements of this type have sometimes revealed inconsistencies indicating the need for further study. An important contribution has undoubtedly been the development of techniques of measurement to an advanced stage, giving reliable operation of measuring instruments in the rocket environment. Of the results obtained, a few examples will illustrate the value of the work. It has been shown that the day-time ionosphere appears to remain dense between the E_1 and F_2 regions, in disagreement with theories suggesting that it is stratified; the F_2 region is much more constant in altitude and lower than previously suggested by ground observations. Measurements with mass spectrometers have given information on the positive- and negative-ion composition of the upper atmosphere, negative ions not being detected on the night flight (115 km.) and positive ions not detected on the day flight (131 km.). The ultra-violet spectrum of the Sun has been studied out to 977 A., a bright emission-line spectrum being photographed in the far ultra-violet. In addition, information has been obtained on the emission of X-radiation. Corrections have been made to the solar constant, resulting in the now generally accepted value of 2·0 cal./min./cm.^{2}. In the northern auroral zone a high intensity of relatively low-energy particles has been detected; these are not protons or heavier particles.

Electronic Temperatures of Planetary Nebulae

Henri Andrillat, of the Observatory at Lyons, has a paper entitled "Les températures electroniques des nébuleuses planétaires" in *Publication de l'Observatoire de Haute-Provence* (3, No. 35; 1957), in which he gives the results of his work on planetary nebulae observable with the 120-cm. telescope at Haute-

Provence. The paper is divided into three parts, the first of which describes theoretical relations between the measurable intensities of the lines and the values of the electronic temperature; and the second deals with electronic temperatures deduced from the intensities of the lines of [O III] measured by the photographic spectrophotometer. Of the two methods mentioned, that using the hydrogen lines allows the extension of the study to fainter nebulae. Twenty-four planetary nebulae were studied and the electronic temperatures obtained ranged between 8,000° and 27,000° K. Comparison of these results with those obtained by others, in particular the photoelectric measurements of Liller and Aller, have led to disagreements which can be explained by taking into consideration the magnitudes of the monochromatic images. From the intensities of hydrogen and helium lines, a correlation is shown to exist between the electronic temperatures and the extent of ionization of the nebula, characterized by the intensity of the helium lines. The third part deals with the continuous spectrum and the Balmer discontinuity of six planetary nebulae, and the experimental results are compared with those of Cillié and of Spitzer and Greenstein. The former give electronic temperatures which are too high, whereas those of Spitzer and Greenstein give temperatures which are too low. Seaton's theory provides results which are in satisfactory agreement, with the exception of N.G.C. 7662, but it is pointed out that his adoption of 13,000° K. for this nebula is inaccurate. It is admitted that, as Seaton has shown (*Mon. Not. Roy. Astro. Soc.*, 114, 154; 1954), it is also possible to compute electronic temperatures starting with the intensities of other forbidden lines.

Space-Group Theory

Of the many X-ray crystallographers who utilize space-group theory in their structure analyses, few have had a systematic training in this theory, and still fewer have read the classical works of Federov, Schoenflies and Barlow in which the 230 space groups are formally derived; most are content to turn to the standard works of reference, such as the "International Tables for X-ray Crystallography", in which the space groups are tabulated without derivation and without emphasis on their interrelationships. In order to meet this difficulty, N. V. Belov published in 1951 (*Trudy Inst. Krist. Acad. Nauk. SSSR*, 6, 25) a 'class-room method' of deriving all the space groups in a systematic manner, based on his teaching experience in the University of Gorkii. This article has now been made available in English in the form of a translation by V. Balashov (*Proc. Leeds Phil. Lit. Soc.*, 8, 1; 1957). Belov's treatment is inspired by the work of Wulff, who directed attention to the fundamental role of planes of symmetry. Starting from this point, Belov derives the 230 space groups, not in the formal sequence of the crystal classes but in an order better adapted to didactic purposes and better suited to bring into prominence the connexions between related groups. The interrelationships of symmetry elements, seemingly so simple, are in fact so subtle that any crystallographer who reads this article is bound to find in it many new ideas and many familiar ideas presented in a new and stimulating guise. The article is an admirable complement to the many other works on space-group theory already available, and its appearance in English translation is most welcome. Offprints of the translation are available at a price of 7*s*. 6*d*. or 1.50 dollars from Austick's Bookshop, 172 Woodhouse Lane, Leeds 2.

Paul Instrument Fund Committee Grants

Awards have been approved as follows: £285 to Dr. J. W. Jeffery, lecturer in physics, Birkbeck College, London, to enable him to carry out crystal structure determination by X-ray diffraction using an instrument for one-dimensional Fourier syntheses employing dekatron counting tubes. £2,000 to Prof. J. D. McGee, professor of instrument technology, Imperial College of Science and Technology, London, to enable him to construct a television system for X-ray image intensification. £11,000 to Dr. V. E. Cosslett, university lecturer in physics, Cambridge, for the further development and improvement of the X-ray microscope: by extending the resolution beyond that of the optical microscope and by attaching an automatic recording mechanism for quantitative analysis of elements. The Paul Instrument Fund Committee, composed of representatives of the Royal Society, the Physical Society, the Institute of Physics and the Institution of Electrical Engineers, was set up in 1945 "to receive applications from British subjects who are research workers in Great Britain for grants for the design, construction and maintenance of novel, unusual or much improved types of physical instruments and apparatus for investigations in pure or applied physical science".

Ramsay Memorial Fellowships Awards

The Ramsay Memorial Fellowships Trustees have awarded fellowships in chemistry for 1958–59 as follows: Mr. G. S. Laurence, a general fellowship at the University of Leeds; a French fellowship to Mme. Mousseron Canet at the Imperial College of Science and Technology, London; a Spanish fellowship to Dr. J. Rodriguez Martinez, at the Atomic Energy Research Establishment, Harwell, and Rothamsted Experimental Station; a United States fellowship to Mr. Phillip G. Thompson at the University of Cambridge. The Trustees have renewed the following fellowships for the same year: Mr. T. E. Peacock (general fellowship) at the University College of North Staffordshire; Dr. D. McK. Wiles (Canadian fellowship) at the University of Leeds; Dr. M. Masui (Japanese fellowship) at University College, London; Mr. J. E. Fergusson (New Zealand fellowship) at University College, London; Mr. P. Arambarri (Spanish fellowship) at Rothamsted Experimental Station; Dr. Diaz Pena (Spanish fellowship) at the University of Reading; Mr. D. Rodriguez (Spanish fellowship) at the University of Sheffield.

Animal Health Trust Awards, 1958–59

The Animal Health Trust has announced the following senior awards for the period 1958–59. *Wellcome Fellowship*: Mrs. H. E. Rose, to investigate the relationship between various members of the Coccidia, using immunological techniques, and to extend the present work on the immune responses of rabbits to *E. stiedae*, to the immune responses, if any, of poultry to their coccidia. This work will be carried out at the Department of Animal Pathology, Cambridge, and afterwards at the Houghton Poultry Research Station, Huntingdonshire. *Research Training Scholarships*: Mr. B. A. Baldwin (Royal Veterinary College, London), to develop methods of assessing the state of consciousness and sensory perception in domestic animals and the physiological aspects of stress associated with the various methods of slaughter of animals ; Dr. A. D. Care, to complete his training for a veterinary degree at the Royal (Dick) School of Veterinary Studies, Edinburgh ; Mr. A. R. Gray, to study the pathology of virus diseases at the Department of Animal Pathology, Cambridge ; Mr. R. F. Sturrock, to study parasitology with special reference to the responses of free-living stages of parasitic nematodes at the Imperial College of Science and Technology, London. Six Evans Final-Year Studentships have also been awarded.

Clayton and Manville Fellowships and Grants, 1958

THE Institution of Mechanical Engineers has made the following awards for special industrial experience, postgraduate studies, or research in mechanical engineering under the terms of the James Clayton Bequest and the Manville Bequest. The total value of the awards is approximately £4,000. *James Clayton Fellowships :* C. R. Evans, for research at the Imperial College of Science and Technology, London, into the stabilization of flames at high speeds ; M. M. Gibson, for research in the University of Liverpool, principally to develop a low-turbulence blower-type wind tunnel for the fundamental study of turbulent boundary layers in two-dimensional flow ; A. F. Pexton, to continue research at the University of Manchester on heat transfer in boiling liquids. *James Clayton Grants :* Dr. M. C. deMalherbe (Johannesburg, South Africa), to visit the United Kingdom to study production methods and for visits to nuclear energy organizations ; D. H. Fleming-Brown (Scotland), to continue studies at Cornell University on reactor containment vessels and on the behaviour of metals at high and low temperatures ; Dr. C. F. Kettleborough (Auckland, New Zealand), to visit British and European universities to study teaching methods, content of courses, laboratory techniques, etc. ; N. Birch (Bristol), to visit the United States to study methods and organization for the manufacture of prototype and aero-engines ; W. H. Emerson, to continue research at King's College, London, on refrigeration ; Dr. J. F. Norbury (Runcorn, Cheshire), to attend the annual meeting of the American Society of Mechanical Engineers to present a paper on fluid mechanics, and for visits to certain universities and research centres in the United States ; *Manville Fellowship :* P. B. Davies, for research at the University College of Swansea on variable-speed transmission of power.

Commonwealth Universities Congress, 1958

THE eighth quinquennial Congress of the Universities of the Commonwealth will be held in Montreal at McGill University and the University of Montreal during September 1–5. Delegations have been appointed by the 109 member universities of the Association of Universities of the British Commonwealth, and the Congress will be attended by 350 members of the teaching and administrative staffs, including 111 delegates from the United Kingdom. The presidents of twenty-seven United States universities and members of the Administrative Board of the International Association of Universities will attend as guests and observers. The opening address, on "Expanding Education", will be given by Sir Hector Hetherington, principal of the University of Glasgow, and at subsequent sessions selected speakers will open discussions as follows : Dr. L. A. Kimpton (chancellor of the University of Chicago) and Dr. V. C. Fowke (Saskatchewan), "Who should determine University Policy ?" ; Prof. J. F. Baker (Cambridge) and Dr. L. A. DuBridge (president of the California Institute of Technology), "Engineering Education and its Place in the University" ; Lord Adrian (vice-chancellor of the University of Cambridge) and Dr. F. G. Soper (vice-chancellor of the University of Otago), "Medical Education and its Place in the University" ; Dr. D. W. Logan (principal of the University of London) and Dr. J. L. Morrill (president of the University of Minnesota), "The Establishment of New Universities". Further information can be obtained from the Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1.

Announcements

DR. S. KRISHNA, scientific adviser in London to the High Commission for India and scientific liaison officer for India, will relinquish his post on August 18. Dr. Krishna's successor has not yet been named ; Mr. B. Sen, assistant educational adviser, India House, Aldwych, London, will be temporarily in charge of the department.

THE British Nuclear Energy Conference, set up in 1955, has increased its membership to nine constituent bodies by the addition of the Joint Panel on Nuclear Marine Propulsion. The Panel consists of four bodies—The Institute of Marine Engineers, The Institution of Naval Architects, The Institution of Engineers and Shipbuilders in Scotland and The North East Coast Institution of Engineers and Shipbuilders.

A CONFERENCE on Gas Discharges, organized by the Physical Society, will be held in the Department of Physics, University College of Swansea, during September 17–20. Further details can be obtained from the Physical Society, 1 Lowther Gardens, London, S.W.7.

A CONFERENCE on Cosmic Rays, organized by the Physical Society, will be held at the Durham Colleges in the University of Durham during September 24–25. Inquiries should be addressed to the Physical Society, 1 Lowther Gardens, London, S.W.7.

A SYMPOSIUM on Cottonseed and its By-products will be held at the Regional Research Laboratory, Hyderabad 9, during December 5–7. Further information can be obtained from the Director, Regional Research Laboratory, Hyderabad 9.

THE eleventh Annual Conference on Electrical Techniques in Medicine and Biology will be held in Minneapolis, Minnesota, during November 19–21. It is sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers and the Instrument Society of America through their Joint Executive Committee on Medicine and Biology. Two hundred and fifty-word abstracts for short contributed papers offered for inclusion in the programme can be sent by October 1 to Mr. Robert Erskine, Minneapolis Honeywell, 2753 Fourth Ave. South, Minneapolis, Minnesota, from whom further information can be obtained.

ERRATUM. We regret that in the article entitled "The Structure of Research in Britain" in *Nature* of July 26, p. 207, paragraph 4, penultimate sentence, the word 'not' has been omitted ; the sentence should read, ". . . it would not appear that Treasury control has been exercised in such a way as to infringe the independence or integrity of science . . ."

THE FIFTEENTH INTERNATIONAL CONGRESS OF ZOOLOGY

IT was a happy choice of the Permanent Committee of International Congresses of Zoology to hold the Fifteenth Congress in London during 1958, the same year as the Darwin–Wallace centenary, and in addition the bicentenary of the publication of Linnæus's "Systema Naturæ", 10th edition, the starting point of modern zoological nomenclature. A total of 1,934 enrolments was received, and although approximately two hundred of these were unable to attend, the result was the biggest attendance of any Zoological Congress since they were started in Paris in 1889. The United States, with more than two hundred enrolments, provided the largest overseas contingent, closely followed by France, and there was a large party from the U.S.S.R.; more than sixty countries of the world were represented. The numbers present were much higher than had been anticipated and threw an extra burden on the officers responsible for making the arrangements for meetings, accommodation, excursions, etc. However, the officers, with H. R. Hewer (secretary-general) and N. D. Riley (registrar), proved equal to any emergency. Registration of members and issue of Congress literature, badges, etc., started at noon on July 14. Each member received a copy of the sixth edition of "The Origin of Species" with a preface by Sir Gavin de Beer; and "Evolution by Natural Selection", comprising Charles Darwin's sketch of 1842, his essay of 1844, an introduction by Sir Francis Darwin (1909), Darwin and Wallace's original communication to the Linnean Society on July 1, 1858, the whole with a foreword by Sir Gavin de Beer.

The inaugural plenary session was held in the Royal Albert Hall, where, in the absence of the honorary president of the Permanent Committee, Prof. M. Caullery, whose death was reported during the Congress, the secretary-general, Prof. Louis Fage, introduced the president of the Fifteenth Congress, Sir Gavin de Beer. In his inaugural address, Sir Gavin referred briefly to the events of the past five years, and in particular to the position of the International Commission for Zoological Nomenclature, and paid a tribute to the valuable work of Mr. Francis Hemming, honorary secretary of the Commission during the past twenty-two years, who on the grounds of ill-health had been compelled to offer his resignation. A colloquium had been meeting during the week previous to the Congress, for the purpose of concluding the revision of the Rules of Zoological Nomenclature. These had been discussed at every Congress since the foundation of the Commission at Monaco in 1892, and especially at Paris (1948) and Copenhagen (1953), but a definitive text had not yet emerged. Sir Gavin stressed the necessity of this text being produced as soon as possible, in order to avoid the confusion of names that would inevitably result in its absence. He continued by emphasizing the value of congresses such as this where zoologists of all branches could meet and discuss their various problems, for there was a danger that, with the increase of specialization, workers might get so far out of touch as to be unable to profit from each other's progress. He also directed attention to the platform party, which included not only the officers and members of the permanent committee but also the members of the Darwin and Wallace families and the heads of the institutions having special associations with the lives of Charles Darwin and Alfred Russel Wallace.

Later in the morning the meeting became public and Sir Julian Huxley gave an inaugural lecture entitled "The Emergence of Darwinism". He first dealt with the development of evolutionary biology during 1858–72, when it was in full flower, until the 1890's, when William Bateson began a reaction which lasted nearly twenty years. This was succeeded by the present phase of Neo-Darwinism in which the basic concept of natural selection is related to the facts of modern genetics, ecology and palæontology. He then developed his theory that man is the chief agent for the future of evolution on this planet, and by building on the foundations of Darwinism we could use the evolutionary concept in considering the history and future development of our species. A science of human possibilities was considered necessary to help in guiding the long course of psycho-social evolution that lay ahead.

The sectional meetings started that afternoon and continued until July 23. The programmes were arranged in twelve sections: general zoology; evolution, taxonomy and genetics; marine zoology; invertebrate zoology; vertebrate zoology; comparative physiology; embryology; parasitology; cytology; ecology; animal behaviour; and zoological nomenclature.

An unprecedented number of papers had been presented for communication and many could only be 'read in title', but all those submitted by members of the Congress will be printed in the *Proceedings*. It is invidious to select any particular communication among the hundreds presented, but an exception must be made of a series of papers dealing with *Neopilina galatheae* and the Monoplacophora, comprising an account of the comparative anatomy of this very primitive mollusc by H. Lemche and K. G. Wingstrand, and molluscan phylogeny and prostomal inter-relationships in the light of *Neopilina*, both by H. Lemche.

The programmes ranged over a very wide field: the communication of zoology; the conservation of Nature; the teaching of zoology; the ancestry of man; the physiological basis of sense perception; neurosecretion; hormones; new approaches in cytology; primate behaviour; flight and migration in birds and insects; ecology and behaviour; to mention only a few of the topics discussed.

The meetings were held in the lecture rooms of the Imperial College of Science and Technology and the Memorial Hall of the Royal Geographical Society. The Reception Room and adjoining rooms in the Students' Union provided an extraordinary and valuable range of services.

The main social functions included receptions at the British Museum (Natural History); the Senate House, University of London; and the Zoological Society of London, in its gardens in Regent's Park; also a private reception by the Shell Petroleum

Company. On Sunday there was an orchestral concert in the Royal Albert Hall in which all the items were associated with animals, and the composer of the overture "The Wasps"—Vaughan Williams—happens to be the grand-nephew of both Charles Darwin and his wife. There were also excursions to Down House, Juniper Hall and Whipsnade Park, in addition to long tours after the Congress.

The final plenary session began with two papers, the first by E. N. Pavlovsky on "Some Modes of Evolution of Infections and Parasitic Diseases", with special reference to work in the U.S.S.R.; the second by J. Millot and J. Anthony, "Resultats actuels de l'étude du Coelacanthe *Latimeria chalumnae* Smith, dernier des Crossoptérygiens", comprising the first detailed account of the anatomy of this interesting archaic fish.

Sir Gavin de Beer then presented the recommendations of the Colloquium on Zoological Nomenclature and mentioned that, under present conditions, it is no longer possible to carry on the work of the Nomenclature Commission on an honorary basis. The International Trust for Zoological Nomenclature, now under the chairmanship of Lord Hurcomb, will have a paid secretary, Mr. R. V. Melville, with a secretarial staff, to undertake the heavy work involved in correspondence and publications. It is hoped that the revised rules of Zoological Nomenclature will be issued within six months.

Sir Gavin also submitted a resolution by Section I "That this widely representative meeting of zoologists from many nations participating in the Fifteenth International Congress of Zoology wishes to place on record in Plenary Session the great urgency of safeguarding the fauna and flora of the Galapagos Islands and welcomes the project, initiated by the International Union for the Conservation of Nature, for establishing on the Islands an International Biological Station for research and for assisting the Authorities of Ecuador in the task of conservation, and trusts that every support will be given by all concerned to the early and successful realization of this vital project".

The resolutions were passed with acclamation and it was then announced that the next Congress would be held in the United States during 1963. Various changes in the Permanent Committee were announced: Prof. J. G. Baer (Neuchâtel) was elected president in succession to M. Caullery (deceased); P. Pierre-Grassé (Paris), secretary-general in succession to L. Fage (resigned); C. F. A. Pantin (Cambridge) and B. Rensch (Münster), in succession to E. Hindle and A. Kühn (resigned); and representatives of four new countries were added, P. Sawaya (Brazil), M. B. Lal (India), T. Jaczewsky (Poland) and J. Uchida (Japan). The new Committee also includes V. d'Ancona (Padua), H. Boschma (Leyden), S. Horstadius (Upsala), A. R. Jorge (Lisbon), E. N. Pavlovsky (Moscow), G. G. Simpson (New York), R. Spärck (Copenhagen), V. van Straelen (Brussels) and E. Witschi (Iowa City), who continue to represent their respective countries.

With the words "Little bear now makes way for big bear", Sir Gavin de Beer introduced the new president of the Permanent Committee, the towering Prof. J. G. Baer, of Neuchâtel, who then addressed the meeting, thus concluding a very successful zoological congress.

EDWARD HINDLE

THE NATIONAL VEGETABLE RESEARCH STATION

MEMBERS' DAY

THE founders' meeting of the National Vegetable Research Station Association took place at the Station at Wellesbourne on June 12. The Association, membership of which is open to anyone interested, aims to foster closer contacts between the research staff of the Station and all concerned with the various aspects of vegetable production in Great Britain. Members elected officers to manage the Association's affairs, and after the meeting the party made a tour of the Station, and members of the staff spoke about their work and demonstrated aspects of it in the field.

The Plant Breeding Section showed first-generation breeding material of spring cabbage obtained under a project to develop a dual-purpose variety, able to be used either for greens or as hearted cabbage. Also on view were the winter-hardy survivors of a number of lines of peas derived from crosses of the hardy maple type with some of the non-hardy commercial varieties. This work was being undertaken in an attempt to develop autumn-sown wrinkled varieties to extend the canning and quick-freezing season. Brief descriptions were given of work on the breeding of non-bolting bunching beet and disease-resistant lettuce, on the production of hybrid onions, and on the inbreeding of brussels sprouts.

The parts of the Pathology Section's work which were demonstrated were those dealing with parsnip canker, tomato stem rot (*Didymella*) and the *Ascochyta* diseases in peas. The natural resistance of parsnip varieties to canker was being tested; existing commercial varieties showed little or no resistance, but some new selections were promising. Members saw plots of outdoor tomatoes being prepared for fungicide tests on *Didymella*, following previous work showing that captan and maneb would greatly reduce the severity of attack. Other diseases being studied included big vein and botrytis diseases of lettuce, clubroot of crucifers, silvering of red beet and mint rust.

The Chemistry Section concentrated on aspects of its field work and several long-term experiments on the mineral composition of soil and plant, soil structure, and plant growth were shown. One of these experiments had made it clear that for crops like brassicas with a high nitrogen requirement, inorganic nitrogen was better than organic, and that no practical advantage was to be gained from splitting dressings of inorganic nitrogen. A nitrogen–phosphorus–potassium factorial experiment, now in its fifth year, showed that large differences in the responses of various crops to levels of phosphorus and potassium could occur; thus potatoes and red beet were showing severe symptoms of potash deficiency on those plots which had had none since the experiment began, while cabbage and carrots had not yet shown any such effects. The laboratory work of this section was concerned with the biochemistry of germination and early growth and with the effect of growth-controlling substances on chemical systems.

The calculation of potential evapo-transpiration of a growing crop from meteorological data had been made possible by the work of Penman and others. The Irrigation Section was developing a practical alternative to these calculations for the commercial grower, and showed a gauge which simulated the water-balance of a plant–soil system and allowed the water deficit at any time to be read off directly. The gauge had been found to give better results than other methods currently available to growers. The section also showed experiments designed to detect the existence or otherwise of moisture-sensitive periods in vegetable crops. Such periods had been found to exist in turnips and peas, and knowledge of them was crucial to good irrigation practice.

The Weeds Section was making ecological studies on the weed seed populations in the plots of the long-term manurial and cultivation experiments, and was also studying the dormancy of weed seeds. The successful use of dinoseb (amine) as a residual pre-emergence herbicide for French and runner beans was demonstrated in the field, also a similar use for simazin on sweet corn.

Various aspects of their work on onions were shown by members of the Physiology Section. These included a trial of varieties for their suitability as pickling onions, and experiments on storage-temperate effects with onion varieties used for the production of sets. Fundamental work being done on competition between crop and weed was mentioned, and members saw a field experiment on one of the practical aspects of this work, namely, the timing of early weeding in row crops. Important depressions in final yield in onions had been shown to result from relatively small delays in the first weeding date.

The Entomology Section presented results from studies on carrot fly and cabbage root fly. Existing methods for controlling carrot fly by seed-dressing followed by top sprays were expensive and sometimes gave but partial control of the pest; new methods using the incorporation of insecticides in the soil were being developed, and low rates of aldrin and dieldrin were found to give complete control of both generations for at least two years. Extensive testing had been done on the effect of soil insecticides on the flavour of carrots and had shown that dieldrin in particular produced little or no detectable changes in flavour. Assays of insecticide residues in the field had been started recently, using *Drosophila*; it had been found that from one application of aldrin at 2 lb. per acre four years previously an appreciable quantity still remained in the soil.

Satisfactory methods for the control of cabbage root fly by insecticides were now known, and attention was being concentrated on the ecology of the pest and the predators of its egg and larval stages. This was begun after it had been found that broadcast application of soil insecticides could lead to increased attack by cabbage root fly larvæ. Recent studies showed that some thirty species of insect were predators of the root fly in its early stages and that they could eat 95 per cent of the eggs laid in a season; it was these predators that were being reduced by the broadcast application of insecticides, and the situation illustrated one of the possible dangers in the indiscriminate use of insecticides in the field. Mention was also made of work on lettuce root aphid and on the control of pea moth.

The Statistics Section was concerned with all the mathematical and statistical problems arising in the work of other sections. In particular, results were being accumulated and methods developed for the analysis of plant growth data, with the object of providing more detailed interpretation of long-term field experiments.

J. A. NELDER

THE MECHANICAL ENGINEERING RESEARCH LABORATORY

MORE than 1,700 visitors from industry, universities, technical colleges and other research organizations attended open days at the Mechanical Engineering Research Laboratory on June 4 and 5. All the work at East Kilbride and Thorntonhall was on show and two new laboratory buildings, completed in 1957, were open for inspection for the first time.

The Metrology Building includes a wing, with a floor area of about 6,000 sq. ft., controlled in temperature to within ± 0·1° of the standard temperature of 20° C. This strict temperature control enables full advantage to be taken of the accuracy of the wide range of precision instruments available for checking the dimensional accuracy of engineering components. The metrology section provides a service to other parts of the Laboratory and to industrial firms ranging from the measurement of surface finish to the certification of the accuracy of large gear-hobbing machines. For the latter work, equipment has been developed for the autographic recording of errors in alignment between the hob-saddle motion and work-table axis of hobbing machines; errors in alignment of 0·0001 in. over a machine traverse of 5 ft. can be recorded. The Mechanisms, Engineering Metrology and Noise Control Division is also developing automatic machines for precision measurement. A prototype measuring bench has been designed for recording errors in precision lead screws: a moiré fringe technique is used and pitch errors are recorded to an accuracy of 0·0001 in. The Metrology Building also houses an anechoic chamber in which the noise-generating properties of complete machines and their component mechanisms can be measured. Preliminary tests on commercial bearings and precision bearings of the same nominal size have shown that the former were noisier, that speed was an important factor and that the radial and axial loads had no significant effect on the noise generated.

The new Heat Building is provided with large quantities of electricity, high- and low-pressure steam, and cooling water for heat-transfer research on a substantial scale. One of the aims of the Heat Division is to provide more accurate basic design data for conventional and novel types of heat exchanger and to analyse the performance of industrial heat-exchange equipment. An experimental rig for measuring heat transfer to regenerator matrices has been used to determine the heat-transfer coefficient for the flow of air through a matrix of randomly packed steel balls. The temperature of the inlet air is varied sinusoidally so that the results are in a convenient form for mathematical analysis.

The Heat Division is also concerned with the preparation of consistent tables of the thermodynamic and transport properties of technically important fluids over wide ranges of temperature and pressure. A DEUCE computer has recently been installed, and is being used principally for this work. A start is being made with argon and carbon dioxide, and it is intended to re-calculate the steam tables and extend their range. Most of these tables will be based on existing data, but some experimental determinations of transport properties are being made. An oscillating disk method is being used to measure the viscosity of gases at moderate temperatures, at pressures up to 100 atmospheres.

The Materials Division is concerned principally with fatigue and creep of metals. It seeks, on one hand, to find out more about the stresses to which components will be subjected in service, and, on the other, to obtain a better understanding of how the material will behave under those stresses. An attempt is being made to explain the mechanism of fatigue damage and failure in terms of dislocation theory. Study of the hardening and embrittlement of mild steel caused by low-stress fatigue loading has shown that, in tensile tests subsequent to cyclic stressing, slip was confined to a few planes which had hardened during the cyclic stressing. This is difficult to account for on a random-network dislocation theory, but can readily be explained if the nature of the preparatory slip is an essential feature of the production of dislocation sources.

Measurements of the propagation of fatigue cracks in thin sheets of various metals have shown that, in the early stages, the rate of growth of a crack is proportional to the current length of crack; at very low stresses, however, non-propagating cracks may form. For fatigue tests on large components, such as railway axles, a novel electronic technique has been evolved which enables rotating–bending tests to be simulated without any rotating parts.

The Materials Division's work on creep is concerned with the behaviour of typical engineering materials under complex-stress systems. For constant loading, the relation between creep-rate, stress and time has been established for a range of metallic alloys at various working temperatures. A generalized version of this relation has now been derived for general-loading complex-stress systems, that is, those in which the stresses are varied during the course of a test. Results of these tests have been compared with various mechanical theories of creep; none of them gave predictions agreeing with the experimental data, although the age-hardening and strain-hardening theories gave upper and lower bounds, respectively. For the special case of relaxation (where the total strain remains constant) a reasonably close prediction of the complex-stress relaxation/time curves was given by the age-hardening theory for an aluminium alloy at 200° C. and a magnesium alloy at 50° C.

The Fluids Division is concerned with basic and applied research on mechanical engineering flow problems, particularly those occurring in water-turbines and pumps, valves, fans and compressors, and oil-pressure mechanisms. Flow measurement is essential in all hydraulic work, and improved techniques have been developed for measuring large rates of flow of liquids in pipes. Electronic equipment has been developed to record the rotational velocity of up to twenty-one propeller current-meters automatically. Advantages over conventional chart recording are convenience and the immediate indication of the number of revolutions in a pre-determined time. A new integration technique has been devised for calculating total flow from point velocity readings (derived from current meters or pitot tubes) in a circular pipe; the mean velocity can be determined with at least as great an accuracy from fewer point readings than equivalent methods. Its use will save time and expense, particularly in field trials. In the salt-velocity method the mean velocity is measured by suddenly injecting into the pipeline a quantity of salt solution of higher electrical conductivity than that of the water. Its passage between two downstream positions, a known distance apart, is timed. Here again electronic techniques have been used to increase the sensitivity of the method and also to provide a direct indication of the time interval. Four flow measurement techniques, the current-meter, pitot-tube, salt-velocity and salt-dilution methods, have been tried out simultaneously in a 40-in. diameter pipeline of a Scottish hydro-electric station at flow rates up to 70 cubic feet per second. Results from all methods agreed within ± 2 per cent of the current-meter values, which were taken as the reference.

Research on hydraulic transmissions is also the concern of the Fluids Division. There is a growing realization in industry that the steplessly variable hydrostatic transmission provides the ideal link between an internal combustion engine and the work it has to do. A 15-h.p. pump-motor has been built with the usual reciprocating pistons replaced by reciprocating balls, resulting in an appreciable reduction in cost. It has an overall efficiency of about 80 per cent for speeds between 1,000 and 3,000 r.p.m. A 40-h.p. axial-type pump-motor has been designed, and fitted with instruments to provide basic design information on piston slipper-pads and port-plates.

The Lubrication and Wear Division undertakes experimental and theoretical investigations of the factors affecting the design and operation of all types of bearings. Gas-lubricated bearings have advantages over conventional oil-lubricated bearings for special applications. Investigations of self-acting air-bearings, where the load-carrying film is generated by hydrodynamic action, have shown that with a conventional clearance of 0·001 in., a 1-in. diameter bearing can carry a load of 1 lb. per sq. in. of bearing area for each 1,000 r.p.m. Such bearings have run successfully at speeds up to 100,000 r.p.m.

A clear understanding of the processes of lubrication and wear is essential if machines are to last long enough to give an adequate return for their cost. New methods of reducing wear often depend on a better understanding of the various factors which cause it. Much attention is therefore given to fundamental studies of physical changes in the structure of surfaces when they are deformed by abrasion or other processes.

The manufacture of almost all metal articles involves plastic deformation of the metal. The Plasticity Division's work is directed towards providing a better understanding of the mechanism of plastic deformation so that economies in plant design and more efficient operation may be achieved. When α-uranium is irradiated with neutrons a greatly accelerated creep takes place, even under small loads. The mathematical theory of plasticity has been applied to explain, in detail, the mechanism of this phenomenon in a uranium aggregate, starting from the known crystallographic properties of a single crystal of uranium.

In many metal-working processes the deformation takes place in the presence of hydrostatic pressure which may be considerably greater than the yield stress of the metal. Equipment has been developed for carrying out simple mechanical tests under pressure up to 100 tons per square inch. Tensile tests on various materials under a range of hydrostatic pressures have shown that there is, generally, a marked increase in their ductility as the pressure is increased. With copper, aluminium and cast-iron the increase in ductility is gradual, with zinc and 'Mazak' (a zinc-base alloy) there is an abrupt change from brittle to ductile behaviour for a small change of pressure. The possibility of extruding brittle materials by carrying out the process under high pressure is being examined. R. J. F. FRANKLIN

ACCURATE MEASUREMENT OF THE VISCOSITY OF LIQUIDS

A SYMPOSIUM on the "Accurate Measurement of the Viscosity of Liquids", arranged jointly by the Institute of Petroleum and the British Society of Rheology, was held on June 6 at the Institute of Petroleum, 61 New Cavendish St., London, W.1. It was under the chairmanship of Mr. W. Pohl (chairman of the Lubrication Committee, Institute of Petroleum) and Prof. E. G. Richardson (University of Durham, president of the British Society of Rheology).

The revised standard methods (British Standard 188 : 57 and Institute of Petroleum, 71 : 58) for measuring the viscosity of liquids in C.G.S. units, which incorporate the experience and the results of co-operative experimental work obtained in Britain and other countries during the post-war years, describe a 'step-up' procedure for the calibration of glass capillary-type viscometers, using master viscometers and freshly distilled water at 20·00° C. with an agreed viscosity of 1·002 centipoises (1·0038 centistokes). Dr. R. Roscoe (University of Durham) pointed out in a paper on the determination of viscosity by the oscillating vessel method that further research on accurate absolute methods of viscosity measurement of liquids as standards is desirable, because of the difficulty in the capillary tube method of the elimination of the end correction. The slight inconsistencies in the careful measurements of J. F. Swindells, J. R. Coe and T. B. Godfrey, who found the viscosity of water at 20·00° C. to be 1·0019 ± 0·0003 cP., arise from small differences in the ends of paired tubes. The oscillating vessel method, advocated by Prof. Andrade and A. Chiong, may prove to be better for accurate viscosity measurements. Dr. Roscoe described a series of precise measurements with water, using oscillating vessels, both spherical and cylindrical, supported by a graduated capillary tube so that the water acted as its own thermometer. In this preliminary work a value obtained for the coefficient of viscosity for water at 20° C. was 1·002 5 ± 0·000 5, but an analysis of the sources of error in the results suggests that with fairly simple improvements in technique, for example, using cylindrical vessels and measuring angular velocity rather than amplitude of oscillation, the accuracy of the method, of the order one part in 10,000, could be substantially greater than that obtained in capillary tube measurements.

The measurement of viscosity by means of a vibrating system using an electronic counting technique was described by Mr. M. T. Browne (Imperial College and Queen Elizabeth College, London), who gave the method of calculating viscosity values for water from the logarithmic decrement, the electronic apparatus counting the number of cycles of vibration occurring while the amplitude decreases from one value to half this value.

For oils of higher viscosity the liquid is located on a plane end of the rod. The apparatus is particularly adapted to measure small changes of viscosity.

In a paper on the precise measurement of kinematic viscosity in the petroleum industry, K. A. Lammiman and P. P. Morris (Esso Research Ltd.) described standard instruments and modern equipment involving electronic timing devices, precisely controlled thermostat baths for a temperature-range from − 100° to 200° C. and above, and the technique used for the scrupulous cleaning of instruments by pressure jets of solvents. The authors described methods of measuring viscosity when only small amounts were available; these required the use of the standard miniature British Standard viscometers, torque viscometers such as the plate-cone type, vibrating systems and a comparative method of the rate of descent of an index of oil (0·05 ml.) in an inclined capillary.

Methods of examining opaque oils and fuel oils and their heat pretreatment were also described, as well as semi-automatic methods using viscometers fitted with platinum probes at the fiduciary markings.

During the past two decades industry has become 'shear' conscious mainly in connexion with the requirements of the Armed Services and the automotive industry. At the rates of shear occurring during flow in standard viscometers, the viscosity does not show variations, but at high rates of shear the coefficient of viscosity is no longer a constant. Dr. R. Schnurmann (Esso Research Ltd.) described a jet viscometer in which frictional heating is practically eliminated when a liquid is forced slowly and in individual drops through a narrow streamlined constriction.

By varying the pressure difference across the aperture or the temperature the rate of shear can be altered over a wide range. The kinetic energy correction can be determined experimentally and is smaller by a factor of 2 than for long capillary viscometers, which usually have a length to diameter ratio of 100.

The viscosity of any liquid containing asymmetric molecules can be made to show a temporary viscosity-fall during flow because of molecular orientation in the flow stream. Castor oil, for example, appears to have a constant viscosity coefficient for rates of shear up to 5,000 sec.$^{-1}$ yet at a rate of shear of 250,000 sec.$^{-1}$ its viscosity is reduced by about 25 per cent. The apparent viscosity over a wide range of rate of shear has a falling characteristic with a point of inflexion, the curve bending upward when an appreciable proportion of the pressure-volume energy is converted into kinetic energy and when turbulent flow takes place. The viscosity of a liquid containing large asymmetric molecules, as in an oil thickened with polymer, which has suffered a permanent viscosity loss through severe shearing, is more sensitive to temperature change than that of the liquid at low rates of shear. On the other hand, when a liquid suffers a temporary viscosity reduction its viscosity–temperature coefficient is smaller while a shearing stress is being applied than when the stress has been removed.

The complexity of the flow behaviour of solutions of some polystyrenes at high dilution was emphasized by Dr. P. P. Rutherford (University College of North Staffordshire), who showed that with a capillary-type viscometer anomalous $\eta sp/c$ and ln $\eta r/c$ values were obtained at the highest dilutions. Upswings in the graphs were observed when these values were plotted against the concentration over the range 0·2–0·4 gm. of polystyrene (mol. weight less than 40,000). The concentration at which these upswings occurred depends on the intrinsic viscosity or molecular weight, the temperature and the kind of solvent used. The flow times for the dilute solutions left in contact with powdered glass for several months were found to be almost unaltered, indicating that adsorption effects on the viscometer walls are negligible. Before an explanation of the anomalies is offered further work is necessary not only on viscosity measurements of fractionated polystyrenes of low molecular weight but also by the measurement of light scattering, density and other properties in the low concentration range.

At the first World Petroleum Congress held at the Imperial College of Science and Technology, 1933, the opinion was expressed by Dr. Guy Barr of the National Physical Laboratory that the international standardization of viscosities should be made with viscometers of known characteristics, as these are much less likely to change than standard viscosity oils. This view is at present maintained by both the British Standards and Institute of Petroleum viscosity committees, and in a short report by Mr. W. O. Jennings (National Physical Laboratory) and Dr. E. W. J. Mardles (chairman of the Institute of Petroleum Viscosity Panel) it was shown by results obtained at the National Physical Laboratory that the average change in the constant of four master viscometers over the period 1953–58 was no greater than + 0·01 per cent.

Information from observation books at the National Physical Laboratory indicated the satisfactory working of the standard methods. The report using these results gives the method of establishing a series of reference viscometers on the basis of the agreed viscosity value of water. The accuracy of the method was assessed by cross checking with other laboratories.

The meeting discussed the various factors by which high precision is attainable and in particular the difficulty of using the quadratic equation, $\nu = Ct - B/t$ where ν is kinematic viscosity, C the viscometer constant, t time of flow and B the coefficient of the kinetic energy of efflux, B being known to be variable. The standard methods indicate ways and means of avoiding the use of B or obtaining a working value for it by calculation.

The experimental determination of term B can conveniently be made, as shown in the report, by first obtaining the value for C, using a flow time not less than 1,200 sec.; then, with a flow time of about, but not less than, 200 sec., evaluating B from the equation $B = Ct^2 - \nu t$, where t is the short flow time and C the constant already obtained.

L. A. Steiner (Viscosity Panel, Institute of Petroleum) described a series of experiments showing the variation of the coefficient B under different conditions of experiment. Using sets of viscometers of the same design but with one variant, namely the capillary diameter, the true constants could be ascertained by a graphical method. It was shown that the variation in the coefficient B could be explained partly by end effects, the shapes of the entry and exit ends of the capillary affecting the results; part of the efflux energy is recovered during the filling of the bulb.

The meeting included the exhibition of some new viscometers and equipment, and was concluded by a visit to the viscometry, chronometry and thermometry sections of the National Physical Laboratory on June 7.

E. W. J. Mardles

THE BRITISH GELATINE AND GLUE RESEARCH ASSOCIATION

The fifteenth meeting of the Research Panel of the Association was held on June 12, with Dr. G. R. Tristram (University of St. Andrews) in the chair. The meeting was well attended and was followed by demonstrations and discussions in the Association's Laboratories at 2*a* Dalmeny Avenue, London, N.7.

The meeting commenced with a review by Prof. A. Neuberger (St. Mary's Hospital Medical School, London), with the title "General Aspects of the Metabolism of Collagen". Prof. Neuberger outlined the development of the use of radioactive amino-acids in studies of the laying down and turnover of collagen, and the part which the soluble collagens play in this. He also described work showing the inability of an animal to make use of free hydroxyproline (and hydroxylysine) in collagen synthesis, the hydroxyproline being formed at some stage by the hydroxylation of bound proline.

Drs. N. M. Green and D. A. Lowther (St. Mary's Hospital Medical School) gave a paper "Biosynthesis of Collagen", describing their recent researches. In these they have made use of tissue slices obtained from the connective tissue tumour formed when carrageenin is injected under the skin of a guinea pig. Two problems were studied: the first, the conversion of proline into collagen-bound hydroxyproline, and secondly, the precursor relationships between the soluble collagens together with the search for other collagen-like precursors in the cells.

The microtomed tissue slices were incubated in a Krebs medium, which included radioactive proline, for 4 hr. at 37° C. under oxygen. After washing, they were ground and the soluble collagens extracted. The results showed that, in all the purified collagen fractions, the radioactivity of the hydroxyproline was comparable with that of proline, showing that it was derived from the radioactive proline in the medium. In addition, the collagen soluble in neutral salt showed a very much more rapid incorporation of radioactivity than acid-soluble collagen, which in turn showed greater activity than the insoluble collagen. The addition of free hydroxyproline to a culture did not lead to a reduction in the ratio of radioactive hydroxyproline to radioactive proline, while the addition of radioactive hydroxyproline to a medium free of radioactive proline showed no significant incorporation into the collagen. Changes in ratio of specific activities for collagen, hydroxyproline and proline with incubation time, in the presence of radioactive proline, suggest that hydroxylation occurs before incorporation into the protein. Further experiments, in which subcellular fractions were isolated from the tissues, showed that collagens soluble in neutral salt are present in certain fractions. It was suggested that there is a continuous series of collagens of decreasing solubility, of which neutral salt-soluble and acid-soluble collagens are two arbitrary fractions.

A lively discussion followed the paper, and a vote of thanks was proposed by Mr. S. Henson (William Oldroyd and Sons, Ltd.) and seconded by Dr. J. E. Eastoe (Royal College of Surgeons).

A number of analytical techniques were included in the demonstrations at the laboratory. In each instance, part or the whole of the determination was carried through for each group of visitors. Mr. A. A. Leach described his modified Neuman and Logan technique for hydroxyproline determination. Mr. W. G. Cobbett and Dr. A. W. Kenchington demonstrated tyrosine estimation by ultra-violet absorption and by a modified colorimetric method. Dr. G. Stainsby showed how the biuret method could be applied to estimating gelatine concentrations, and Mr. J. T. Taylor carried out the Kodak test for the setting time of a gelatine solution. Mr. A. M. Kragh showed the powerful action of gelatine and glue as flocculation and filtration aids, when used in the correct conditions.

Much interest was aroused by the demonstration by Dr. A. Courts of the properties of a form of soluble collagen which can be isolated from collagenous tissues after they have received pretreatments of the type used in gelatine manufacture (for example, a cold alkaline soak). Substantial percentages of the collagen could be solubilized in this way using 0·1 *M* citric acid as solvent. The solution was very viscous but, on warming to 43° C., a rapid conversion to gelatine occurred, and the viscosity fell more than 40-fold to a normal value for gelatine. It was possible to precipitate the soluble collagen as fibre by the same procedures as applied to acid-soluble collagens from native tissues. It appears clear that bonds formed when the collagen became insoluble have been broken, enabling the original structural units to be dissolved.

Also on show were equipment for fractionation (W. B. Langston), small-scale gelatine extraction (F. W. Wainewright and A. P. Williams), and the use of *XE* 97 resin for the separation of gelatine components by the method of G. E. Russell (Ilford, Ltd.) (A. A. Leach). A. G. Ward

NUMERICAL WEATHER FORECASTING

THE methods of numerical prediction by electronic computer of the atmospheric pressure field now being investigated are based on finite difference approximations to the differential coefficients in the equations of motion. It is required to forecast the variation with time of the height h of an isobaric surface, and the differential coefficients of this quantity occur in the equations.

Starting with a set of values of h at the grid points of a map, the finite-difference approximations can be computed from more than one set of combinations of the values. The effects of using different combinations have been examined in the numerical forecasting research unit of the Meteorological Office, and the results are published in a recent paper entitled "Experiments in Numerical Integration", by E. Knighting, D. E. Jones and Mavis K. Hinds (*Quart. J. Roy. Meteor. Soc.*, 84, 91; 1958).

The quantities which have to be computed are the Laplacian $\frac{\partial^2 h}{\partial x^2} + \frac{\partial^2 h}{\partial y^2}$ and a Jacobian $J(h,\zeta)$, where ζ is the vertical component of the vorticity, which in turn is expressed as a function of the Laplacian.

The grid points are arranged in square sets. One basic set of grid points is that of the eight points at the centre, corners and mid-points of the sides of a square. These are numbered 0 at the centre, 1, 2, 3, 4 at the mid-points of the sides—with the easternmost point of this set 1, northern 2 and so on counter-clockwise—and 5, 6, 7, 8 at the corners—with the north-east point 5 and the north-west point 6 and so on as before. Then one finite-difference approximation to the Laplacian is:

$$(h_1 + h_2 + h_3 + h_4 - 4h_0)/a^2$$

where h_i is the value of h at point i and $2a$ is the length of a side of the square. Another approximation is:

$$(h_5 + h_6 + h_7 + h_8 - 4h_0)/2a^2$$

Similar, more elaborate combinations apply to the Jacobian.

The authors describe the results of using these different combinations on actual meteorological situations, one of which is the great north-westerly gale of January 31, 1953, which led to the North Sea floods of the following night. Considerable differences are found to occur between the maps of the predicted pressure distributions according to the particular combinations employed. These differences occur even in the centre of the large area dealt with, though that is the part in which, because of its distance from the edges with their specified boundary conditions, errors are usually smallest. The difference between two combinations was about 40 per cent of the actual change in two cases and 10 per cent in a third.

These are serious differences, and the authors point out that on some occasions the choice of a geometrical method of making the finite difference approximations has a decisive effect on the forecast. The differences are believed to be associated mainly with the Jacobian, and the authors consider the remedy will have to be sought by using more complicated finite-difference approximations for the derivatives. This would, of course, mean greater complexity and time in the computation.

RIBONUCLEIC ACIDS IN LIVER CYTOPLASM

By Dr. E. REID and BARBARA M. STEVENS

Chester Beatty Research Institute, Institute of Cancer Research : Royal Cancer Hospital, London, S.W.3

STUDIES in this laboratory on cytoplasmic ribonucleic acid, as influenced by induction of liver tumours[1] or by a change in hormonal status[2-4], have emphasized the need for closer study of the ribonucleic acid in the microsomal and supernatant fractions obtained from normal liver. Microsomal ribonucleic acid and supernatant-fraction ribonucleic acid may differ in function[4,5]; they undergo different changes after adrenalectomy[2-4], and differ in the time of maximum labelling after injection[4] of orotic acid-6-^{14}C [4]. Labelling data[4] were compatible with, but did not prove, the postulate[7,8] that microsomal ribonucleic acid is derived from ribonucleic acid in the supernatant fraction. Supernatant-fraction ribonucleic acid might be derived from acid-soluble nucleotides rather than from nuclear ribonucleic acid[9,10], but no evidence to support this possible relationship emerged from a comparison of the labelling of acid-soluble uridine nucleotides with that of cytoplasmic ribonucleic acid, after injection of labelled orotic acid[6].

The study of precursor-product relationships *in vivo* is hampered by the apparent heterogeneity of the ribonucleic acid in microsomal[11-14] and supernatant[4,8,11,12] fractions. Published procedures[12-18] were not ideal for the purpose of partitioning the ribonucleic acid among several sub-fractions. This purpose has now been achieved by fractionating tissue proteins (ribonucleoproteins ?) under mild conditions as described below, with tissue samples isolated at different times after injection of orotic acid-6-^{14}C; the time course of ribonucleic acid labelling served as a guide in choosing conditions for separation.

Tissue fractions. Liver homogenates, prepared with 0·25 *M* sucrose from fasted rats given labelled orotic acid, were freed from nuclei and mitochondria, and centrifuged for 90 min. at 14,500 *g* to give microsomal and supernatant fractions[3,4]. (The 'ultracentrifugal pellet' which can be obtained by re-centrifugation at a higher *g* value, and which would be included in the 'microsomal' fraction in some laboratories[5,13], resembles our 'ultracentrifugal supernatant' fraction rather than our microsomal fraction in its time course of labelling[4,8] and in its changes after adrenalectomy[2-4] or in liver tumours[1].) The fractions were frozen and stored at − 30°; with microsomal fractions the freezing facilitated the subsequent extraction of ribonucleoprotein.

Analytical methods. Solid samples were counted at infinite thickness, and analysed for ribonucleic acid as previously[3,4]. Almost all the original ribonucleic acid was recovered in the sub-fractions[13,17]. For the subsequent isolation of ribonucleic acid mononucleotides, digestion was performed with 1·5 *N* potassium hydroxide for 42 hr. at 37°, to ensure complete conversion of the ribonucleic acid to mononucleotides[19,20]. The digest was treated with perchloric acid (to 3 per cent) to remove protein, neutralized with potassium hydroxide, centrifuged to remove perchlorate, and applied to a 'Dowex 1' (formate) column. Gradient elution chromatography was carried out with formic acid[21] to give individual nucleotides, with no attempt[20] to separate 2′- and 3′-isomers. The extinction readings (260 mμ) were assumed to be a valid measure of the amounts present, except for cytidylic acid which, being contaminated with protein[20], was estimated by analysis of the peak for phosphorus. A further difficulty with cytidylic acid is that some deamination, to give uridylic acid, may occur during the digestion[20,22]; however, this deamination was probably slight because of the presence of tissue protein[19]. Values are expressed relative to guanylic acid as being probably least open to errors of estimation, and are quoted as 'apparent' base composition, since there may still be undetected errors in the present methods. The radioactivity of nucleotide solutions was determined at infinite thinness, with aliquots dried on duralumin planchets.

Supernatant fraction. All fractionations were carried out at about 2°. The procedure for the supernatant fraction (Fig. 1) was based on previous experiments[4]. The ribonucleic acid precipitated by calcium ions partially redissolved on treatment with oxalate[14]. Both the residual ribonucleic acid and the re-dissolved portion which remained soluble on adding streptomycin sulphate[18] seemed, on the grounds of labelling results, to be worthy of closer examination, together with ribonucleic acid precipitated from the calcium-soluble fraction by ammonium sulphate[4] at 40 per cent of saturation. There appeared to be differences in base composition (Fig. 1), the last-named fraction being deficient in guanine; but attention is directed particularly to the differences in the time course of ribonucleic acid labelling (Fig. 2). The peak of labelling lay at about 12·5 hr. for the ammonium sulphate (40 per cent) precipitate, at about 20 hr. for the streptomycin supernatant and not earlier than 42 hr. for the residual (oxalate-insoluble) ribonucleic acid. (Note logarithmic axes.)

If the ribonucleic acid with a peak at 12·5 hr. were the precursor of that in other sub-fractions, it should have relatively high labelling up to 12·5 hr.[23]. Here it is necessary to consider the labelling not of ribonucleic acid as a whole but of the uracil moiety, since, as has now been confirmed, the labelling of

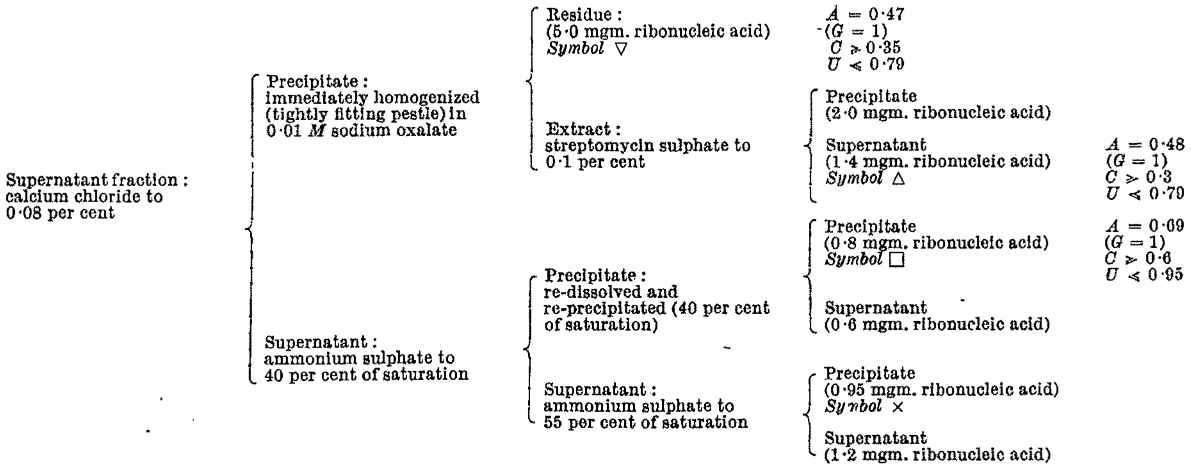

Fig. 1. Sub-fractions from supernatant fraction. In Figs. 1 and 4, the yields of ribonucleic acid refer to an amount of liver corresponding to 100 gm. body weight; the symbols are those used in Figs. 2–6, and *A*, *G*, *C* and *U* denote adenylic, guanylic, cytidylic and uridylic acids, respectively. The mean values for the apparent base composition (see text) are given as molar ratios

cytosine is initially low but eventually as high as that of uracil[6]. Fig. 3 shows that the ribonucleic acid uracil of this sub-fraction does rapidly attain high labelling.

Since it was conceivable that the 'rapidly labelled ribonucleic acid' comes directly from acid-soluble nucleotides, possibly uridine triphosphate or uridine diphosphate[10], these nucleotides were isolated for study[4,6,21]. There was no wide gap[6] between their peak of labelling and the peak for the 'rapidly labelled ribonucleic acid' (Fig. 3). In contrast with uridine triphosphate, the diphosphate had persistently high labelling which greatly exceeded that attained by ribonucleic acid uracil. It should be mentioned that all experiments were made with a single batch of orotic acid (prepared by Dr. V. C. E. Burnop); with a different batch (from the Radiochemical Centre, Amersham) used in another study[1], higher nucleotide and ribonucleic acid labelling has been encountered at short time intervals.

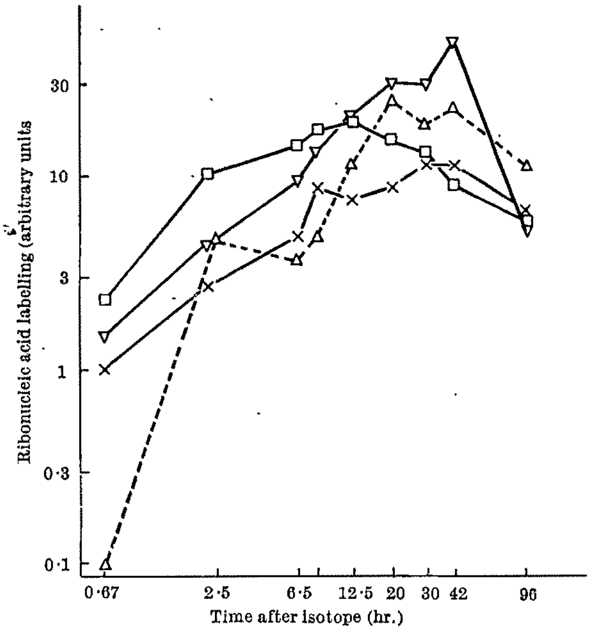

Fig. 2. Labelling of ribonucleic acid in sub-fractions from the supernatant fraction (see Fig. 1 for symbols). The axes in Figs. 2, 3, 5 and 6 are logarithmic, and the values refer to an injection of orotic acid equivalent to 1 μc./100 gm. body weight; each point represents tissue samples from at least two rats. The arbitrary units in which specific radioactivity is expressed in Figs. 2 and 5 are (counts per min.)/(per cent ribonucleic acid in sample counted), with constant sensitivity in the counting

Trial of an alternative fractionation procedure—precipitation at *p*H 5 in the presence or absence of buffer—indicated that the course of labelling of the precipitated ribonucleic acid (which may play a part in amino-acid incorporation[5]) resembled that of the soluble ribonucleic acid. The procedure of Kirby[24] also failed to give sharp separation.

Microsomal fraction. Fig. 4 summarizes the procedures. Ribonucleoprotein particles (Palade particles) from microsomes would probably be essentially intact if present in the *p*H 7·4 buffer or even in the *p*H 9·0 buffer[16]. Since, however, the residue

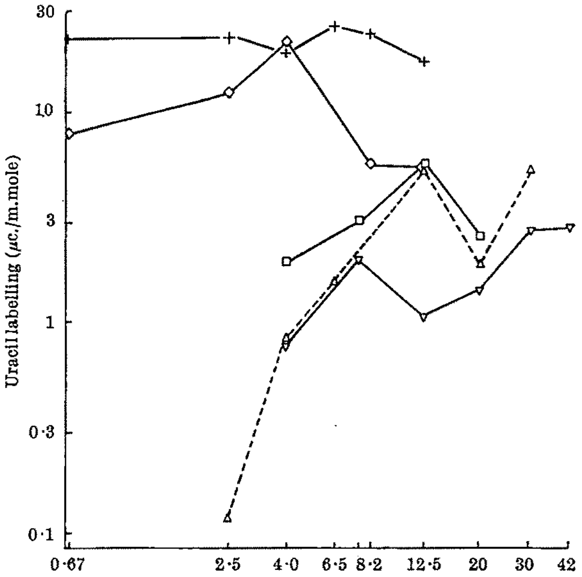

Fig. 3. Labelling of uracil in the ribonucleic acid of sub-fractions from the supernatant fraction (see Fig. 1 for symbols), and labelling of uridine diphosphate (+) and of uridine triphosphate (◇) in the acid-soluble fraction from whole liver

- Microsomal fraction (re-suspended in 0·25 *M* sucrose solution): 0·15 *M* sodium phosphate buffer, *p*H 7·4, 0·5 vol.; after 15 min., centrifuged for 1 hr. at 14,500 *g*
  - Extract: 0·2 *M* sodium acetate buffer, *p*H 5·0, 0·8 vol.
    - Precipitate (re-dissolved in sucrose + *p*H 7·4 buffer): streptomycin sulphate to 0·2 per cent
      - Precipitate (0·6 mgm. ribonucleic acid) *Symbol* ● — $A = 0{\cdot}5$ $(G = 1)$ $C \geqslant 0{\cdot}7$ $U \leqslant 0{\cdot}9$
      - Supernatant: ammonium sulphate to 45 per cent of saturation
        - Precipitate (1·25 mgm. ribonucleic acid) *Symbol* ■ — $A = 0{\cdot}39$ $(G = 1)$ $C \geqslant 0{\cdot}35$ $U \leqslant 0{\cdot}80$
        - Supernatant (0·5 mgm. ribonucleic acid)
    - Supernatant (0·7 mgm. ribonucleic acid)
  - Residue (re-suspended in sucrose solution): 0·3 *M* sodium glycine buffer, *p*H 9·0, 0·5 vol.; after 15 min., centrifuged for 1 hr. at 14,500 *g*
    - Extract: 0·2 *M* sodium acetate buffer, *p*H 5·0, 1 vol.
      - Precipitate (2·3 mgm. ribonucleic acid)
      - Supernatant (0·4 mgm. ribonucleic acid) *Symbol* ○ — $A = 0{\cdot}4$ $(G = 1)$ $C \geqslant 0{\cdot}8$ $U \leqslant 0{\cdot}6$
    - Residue (re-suspended in sucrose solution): 'Triton X-100' to 0·3 per cent, then streptomycin sulphate to 0·2 per cent
      - Precipitate (1·5 mgm. ribonucleic acid) *Symbol* ▲ — $A = 0{\cdot}45$ $(G = 1)$ $C \geqslant 0{\cdot}4$ $U \leqslant 0{\cdot}71$
      - Supernatant (1·3 mgm. ribonucleic acid) *Symbol* ▼ — $A = 0{\cdot}53$ $(G = 1)$ $C \geqslant 0{\cdot}8$ $U \leqslant 0{\cdot}65$

Fig. 4. Sub-fractions from microsomal fraction. See legend to Fig. 1

from the *p*H 9·0 extraction was still rich in these particles as judged by electron microscopy (kindly performed by Mr. M. S. C. Birbeck), it is conceivable that the ribonucleic acid extracted by buffer is derived not from these particles but from reticular elements[11]. The non-extracted ribonucleic acid was effectively solubilized by treatment with the non-ionic detergent 'Triton X–100'; treatment with phenol[24] was equally effective, but subsequent fractionation procedures[24] gave rather variable results.

Two fractions from the first (*p*H 7·4) extraction were given especial attention—a streptomycin precipitate, and an ammonium sulphate precipitate which had a later peak of labelling (Fig. 5). The ratio of adenine to guanine differed little among these and other sub-fractions examined, but there were apparent differences in the ratio of cytosine to uracil (Fig. 4). The *p*H 5-soluble material from the second (*p*H 9·0) extract showed labelling which was variable but notably low (Fig. 5). The residual ribonucleic acid which was solubilized by the detergent gave, with streptomycin, a precipitate which had an earlier peak of labelling than the supernatant.

Values obtained for uracil (Fig. 6) were essentially in accord with those for the labelling of ribonucleic acid as a whole. Comparison of the curve for the

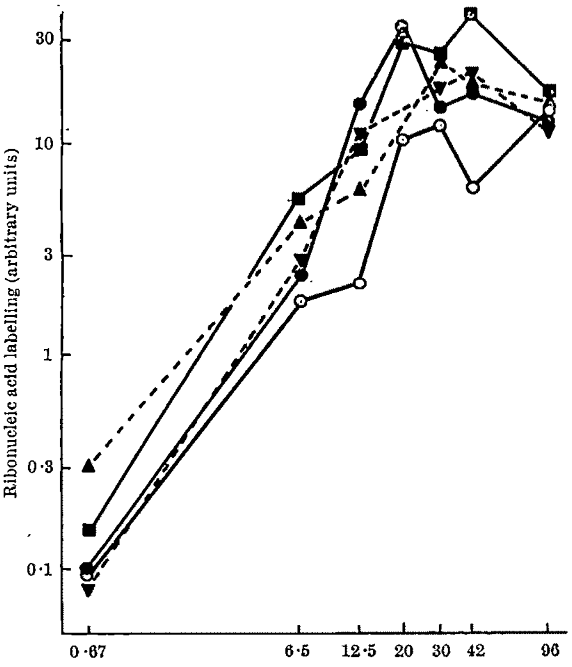

Fig. 5. Labelling of ribonucleic acid in sub-fractions from the microsomal fraction. See Fig. 4 for symbols, and legend to Fig. 2 for units

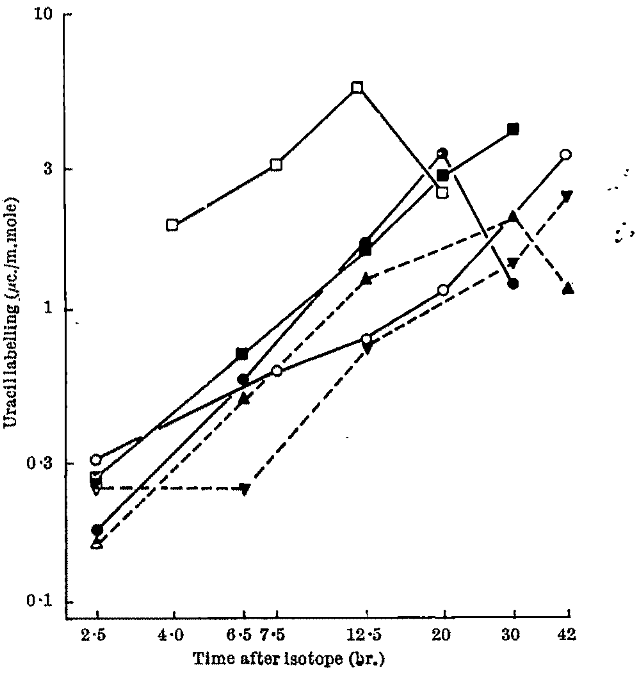

Fig. 6. Labelling of uracil in the ribonucleic acid of sub-fractions from the microsomal fraction (see Fig. 4 for symbols) and in the ribonucleic acid of the 'rapidly labelled sub-fraction' from the supernatant fraction (□; cf. Fig. 3)

microsomal sub-fraction having the earliest peak (at about 20 hr.) with the curve, reproduced from Fig. 3, for the 'rapidly labelled ribonucleic acid' from the supernatant fraction suggests that here there could be an inter-relationship[23].

Conclusions. With rats given labelled orotic acid, differences have been found in time and magnitude of maximum labelling among ribonucleic acid sub-fractions derived from microsomal and supernatant fractions; the results agree with the finding[4] that the supernatant fraction as a whole becomes labelled earlier than the microsomal fraction. The peaks ranged from about 12·5 to more than 42 hr., the earliest being observed with ribonucleic acid separated from the calcium-soluble portion of the supernatant fraction. Qualitatively, the results are not incompatible with the possibility that this 'rapidly labelled ribonucleic acid' is formed directly from acid-soluble nucleotides, and is a precursor, direct or indirect, of other ribonucleic acid constituents of the supernatant and microsomal fractions. There appear to be differences among the sub-fractions in base composition. Speculation on possible chemical transformations undergone by the 'rapidly labelled ribonucleic acid' must await further study, especially as to the homogeneity and molecular size of the various ribonucleic acid constituents. The microsomal sub-fractions warrant study with respect to amino-acid incorporation into protein, but this incorporation may well be uncorrelated with ribonucleic acid labelling[13,14].

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AGE DETERMINATION FOR INDIVIDUAL *MANSONIOIDES* MOSQUITOES

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The age of the individual insect living entirely naturally has long challenged the interest and ingenuity of entomologists in many fields. For medically important insects, one of many factors in the epidemiology of the diseases they carry is the proportion of a population of a vector species living long enough to transmit pathogens which undergo, before transmission can take place, cyclical development within the insect for some days or weeks. Means of telling the age of mosquitoes—vectors of malaria, filariases and virus infections involving extrinsic cycles of this nature—have been sought from time to time by numerous workers, notably for anopheline carriers of malaria.

The most promising and useful methods still depend on changes in the internal reproductive organs of the female mosquito during its gonotrophic cycles. In each cycle it matures and eventually lays its eggs in the few days following a blood meal; there may be several gonotrophic cycles, each lasting two or more days, in the life-time of a mosquito. Mer[1] showed first for *Anopheles elutus* that the ampulla, a dilatation of the oviducts, increased in diameter with the first oviposition to a degree which served to differentiate recently emerged females which had not laid eggs from older individuals which had laid one or more batches. Later workers confirmed this method for distinguishing nulliparous from older, parous females in some other anopheline species; Davidson[2] elaborated the principle on a statistical basis to derive a daily survival-rate for *A. gambiae*. New departures were made by Gillies in the recognition of young females (pre-gravids) of this species on the basis of partial ovarian development only after their first blood meal[3], and by the presence of a mating plug in the common oviduct[4]. The undoubted value, and also limitations of these, and certain other methods, for determining the longevity of mosquitoes are indicated by Macdonald[5] in his analysis of factors in the epidemiology of malaria. It may be emphasized here that none of these methods is suitable for telling the actual age of the individual mosquitoes making up the older, parous group. This leaves much to be desired. Thus, in favourable climatic conditions nullipars are generally no more than about two or three days old; parous females may be only a day or so older or have lived nearly as long as, or longer than, the extrinsic period of the parasites they may happen to harbour, usually a period of 10–14 days. The last may be actively transmitting the disease, the others may yet survive to do so. In mosquito control work, it would be invaluable to be able to determine with considerable accuracy the age of any individual mosquito caught in the control area. This would be particularly convenient in the early detection of individuals resistant to insecticide in a surviving mosquito population of very low density. It would also be relevant to checking the efficacy of control in the earlier phases of an eradication scheme or where, for various reasons, it may only be practicable to prevent transmission by reducing mosquito longevity to less than the extrinsic period of the pathogen. Apart from practical issues of this kind, accurate age determination of individual mosquitoes would be of immense interest in purely biological studies on their behaviour.

Recently, there have been notable developments towards a solution to this problem. Russian workers, in fact, made important progress in this direction nearly a decade ago. Several months ago, Dr. M. T. Gillies prepared translations of papers published by Polovodova[6] and Detinova[7] in 1949, advance copies of which he kindly made available to us, and others. The Russian work showed for *Anopheles maculipennis* that when an egg passes from its follicle at oviposition it leaves behind a corpus luteum in the form of a dilatation of the tube connecting the ovariole to the lumen of the oviduct in the ovary. This persists through subsequent gonotrophic cycles, each of which in turn is marked by a residual corpus luteum. Thus, the number of these corpora lutea in an ovariole indicates the number of gonotrophic cycles completed by the mosquito. If the duration of a cycle is known, it is then possible to tell the age of the individual mosquito with considerable precision. Some ovarioles do not produce an egg in every cycle, so that the maximum number of corpora lutea per ovariole must be noted. A fuller account of the Russian work has been prepared by Gillies[8]. Recent independent studies by Colless[9] on certain Malayan culicines seem to demonstrate the same criterion for age determination in three species of *Culex* and in *Aedes albopictus*. Lewis[10] reports some preliminary observations on the ovarioles of *A. gambiae* but does not develop the subject beyond the recognition of nulliparous from parous females.

Species of *Mansonioides* are among the mosquitoes of medical importance, primarily as vectors of filariasis of man in the Oriental region, but with some implications also as possible vectors of yellow fever and other viruses. They can be a severe biting nuisance. Their role as vectors of parasites and disease to animals, and possibly man, may well be shown in future to be greater than is generally accepted at present. Colonies of several species of *Mansonioides* have been maintained in our laboratory for about three years using the methods of Laurence and Smith[11]. It was convenient and of interest, therefore, to examine the possibility of determining the age of individual *Mansonioides* females by a count of their corpora lutea, as described for *A. maculipennis* and suggested for *Culex* and *Aedes*. This article reports that in the *Mansonioides* mosquito a corpus luteum remains to mark each gonotrophic cycle and that the maximum number of corpora lutea found in the ovarioles of its ovaries is a valuable index to the actual age of the mosquito.

The experiments demonstrating this were, briefly, as follows: adult mosquitoes were kept in 25 cm. cube cages of wood frame and plastic netting at 26–30° C., humidity within the cages being maintained by damp lint on top of the cages, which were also draped with a thin polyethylene case. Except when being starved before a blood meal, the adults had access in their cages to cut apple and to sugar solution in cotton-wool. Females were fed on blood by inserting the human hand inside a cage. They first fed readily three days after emergence. Gorged females were transferred to a separate cage, as described, and became gravid four days later. When removed to large beakers containing water and floating *Salvinia*, they oviposited on the plant almost at once. In these experiments, a second blood meal was given within 12–18 hr. of oviposition. The second gonotrophic cycle was completed in four days. This procedure was continued with *Mansonioides uniformis* and *M. annulifera* through, respectively, six and three cycles, and representative females were dissected at suitable intervals for ovariole structure. The ovaries were dissected out in 0·9 per cent saline. Ovarioles were then released by breaking the membrane investing the ovary with a fine needle and teasing the tracheal supply aside carefully. With some practice, the corpora lutea could be exposed with considerable ease and counted under a stereoscopic microscope magnifying at × 30.

Results are given in Table 1, and illustrated in Figs. 1 and 2. Fig. 1 shows the germinal area, first follicle and simple pedicel in the ovariole of a three-

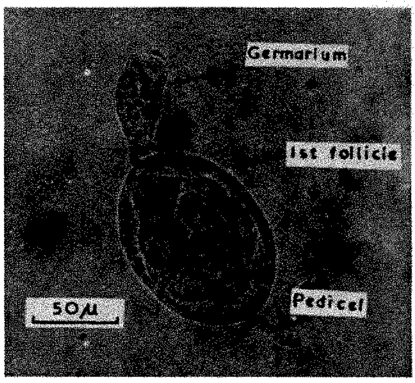

Fig. 1. Ovariole of 3-day old nulliparous *M. uniformis*

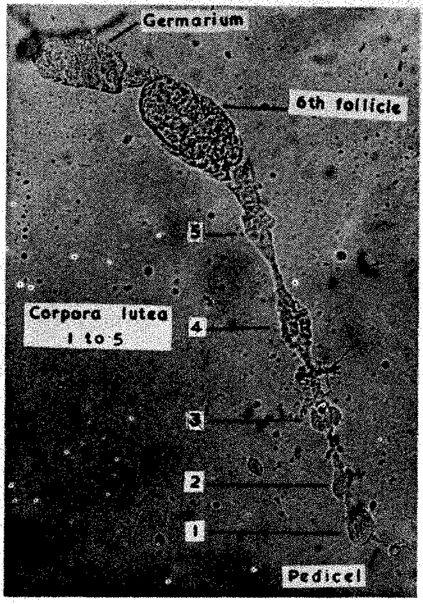

Fig. 2. Ovariole of 23–24-day old parous *M. uniformis*, after five gonotrophic cycles. (Magnification as Fig. 1)

day-old, unfed *M. uniformis* female. Fig. 2 is an ovariole isolated from the ovary of a 23–24-day-old female of *M. uniformis* after five blood meals and ovipositions had been completed. The five corpora lutea each represent a gonotrophic cycle lasting about four days and the first blood meal was given when the mosquito was three days old. Agreement is very close indeed between the actual known age of this individual and the calculated age, based on the number of corpora lutea found and the time required for each gonotrophic cycle. Other individuals killed earlier in the series and with fewer gonotrophic cycles completed showed corresponding maximum numbers of corpora lutea in the ovarioles. Similar results were obtained with *M. annulifera*. These results demonstrate for *Mansonioides* findings similar to those reported for *A. maculipennis*, *Culex* spp. and *Aedes albopictus*. This method of telling the age of any individual mosquito seems, therefore, likely to be widely applicable in mosquitoes generally. It promises to be of great value in elucidating problems in mosquito behaviour, either natural or under pressure of control.

Table 1. Showing, for *M. uniformis*, the Maximum Number of Corpora Lutea in an Ovariole in Relation to the Experimentally Known Age and Physiological State of the Mosquitoes

	Maximum number of corpora lutea in an ovariole	Age of females in days
Emerged and unfed	0	3
After first oviposition	1	7–8
After second oviposition	2	11–12
After third oviposition	3	15–16
After fourth oviposition	4	19–20
After fifth oviposition	5	23–24
After sixth oviposition	6	27–28

Acknowledgment is made to Mr. S. A. Smith of this Department for the photographs.

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INDUCTION OF RESPIRATORY DEFICIENCY IN YEAST BY MANGANESE, COPPER, COBALT AND NICKEL

By Prof. CARL C. LINDEGREN, SUSUMU NAGAI and HIDEKO NAGAI

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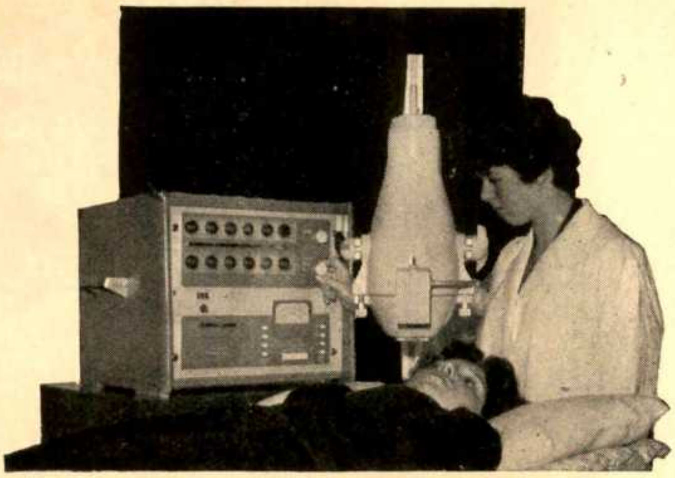
AMONG the chemical agents which induce respiratory deficiency in yeasts, acriflavine[1], triphenyl tetrazolium chloride[2], *p*-nitrophenol[3], and propamidine isethionate[4] are especially effective in producing the deficiency in a large fraction of the surviving population. The present work is a survey of the efficacy of various metallic salts in inducing respiratory deficiency.

Respiratory-sufficient yeasts containing fewer than 1 per cent respiratory-deficient cells when grown under normal conditions were chosen from the Lindegren breeding stocks. Efficacy in inducing respiratory deficiency (during growth) was tested by growth in the following nutrient medium (to which the various agents to be tested were added later): magnesium sulphate ($MgSO_4.7H_2O$), 0·5 gm.; potassium dihydrogen phosphate, 1 gm.; ammonium sulphate, 1·5 gm.; 'Bacto' peptone, 1·8 gm.; 'Bacto' yeast extract, 2 gm.; glucose, 10 gm.; U.S.P. agar, 20 gm. dissolved in 1,000 ml. of water. Concentrated stock solutions of the various agents (usually 2·5 per cent) were sterilized separately and added to the medium at temperatures around 50° C.

Respiratory deficiency was scored by the triphenyl tetrazolium chloride-overlay method[5]. (1 mgm./ml. of triphenyl tetrazolium chloride was dissolved in molten 1·5 per cent 'Bacto' agar adjusted to *p*H 7·0 with *M*/15 phosphate mixture, cooled to 50° C., gently poured over the diagnostic plate cultures and incubated at 30° C. Respiratory-sufficient colonies turn dark red within an hour while respiration-deficient colonies remain white.) Medium for the



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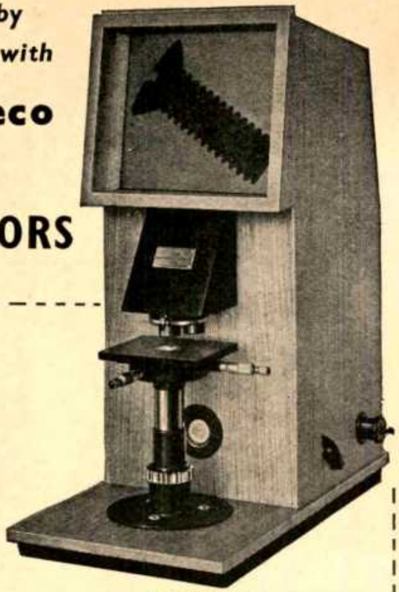

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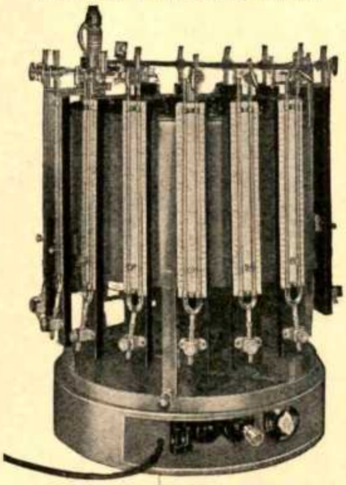

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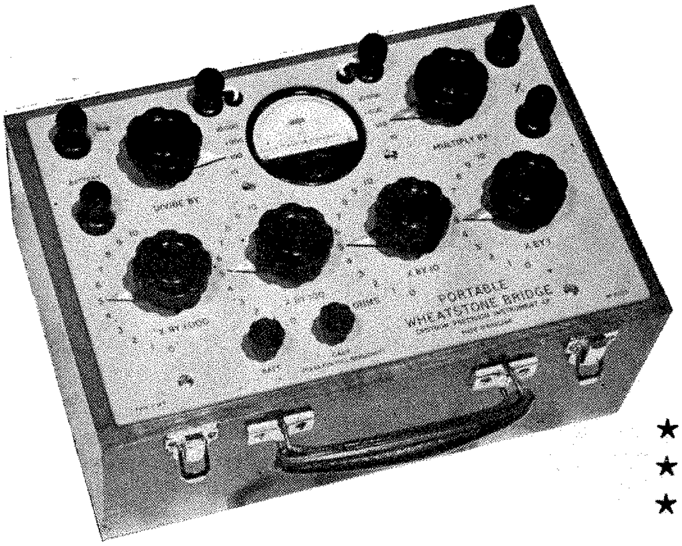

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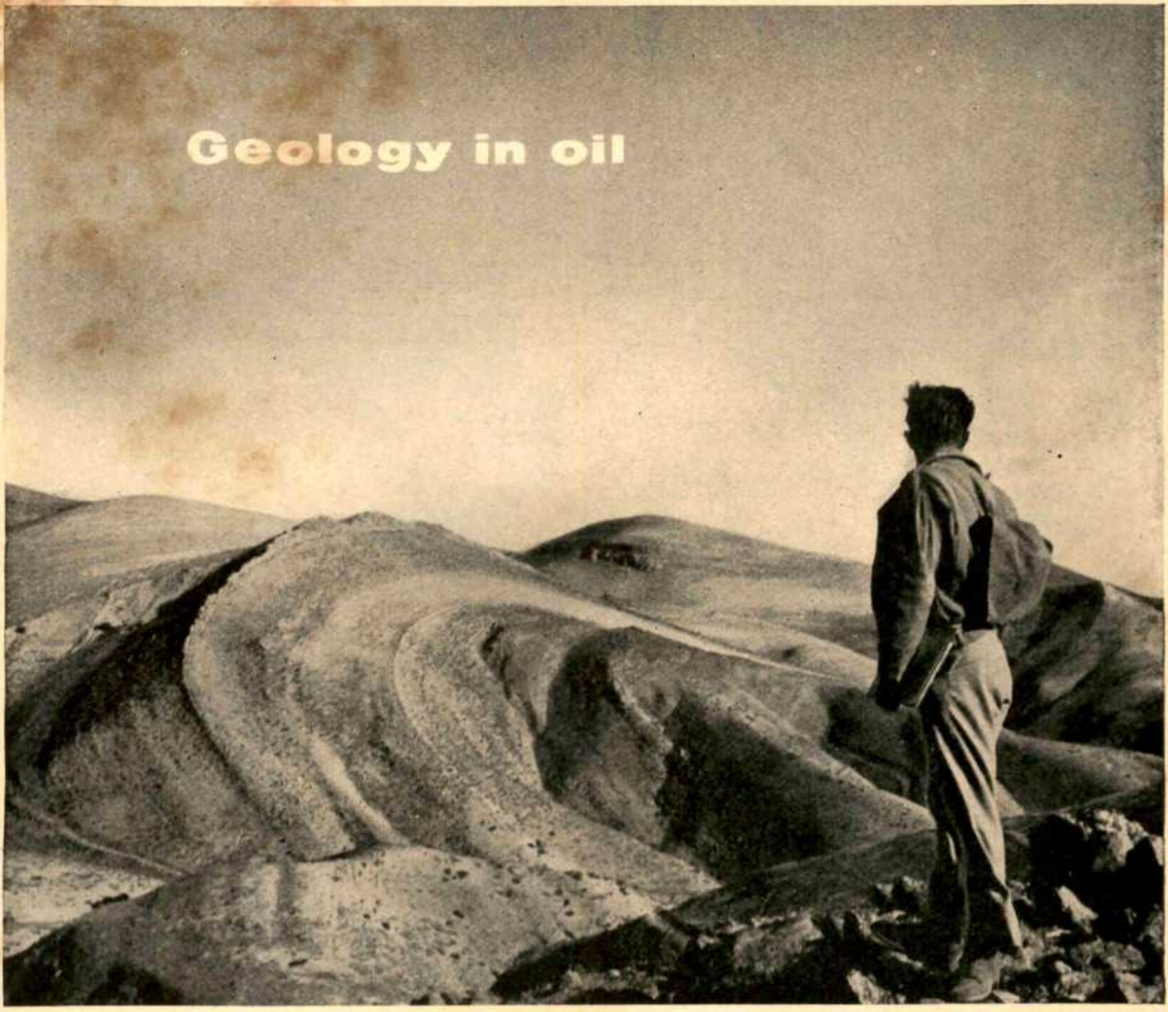

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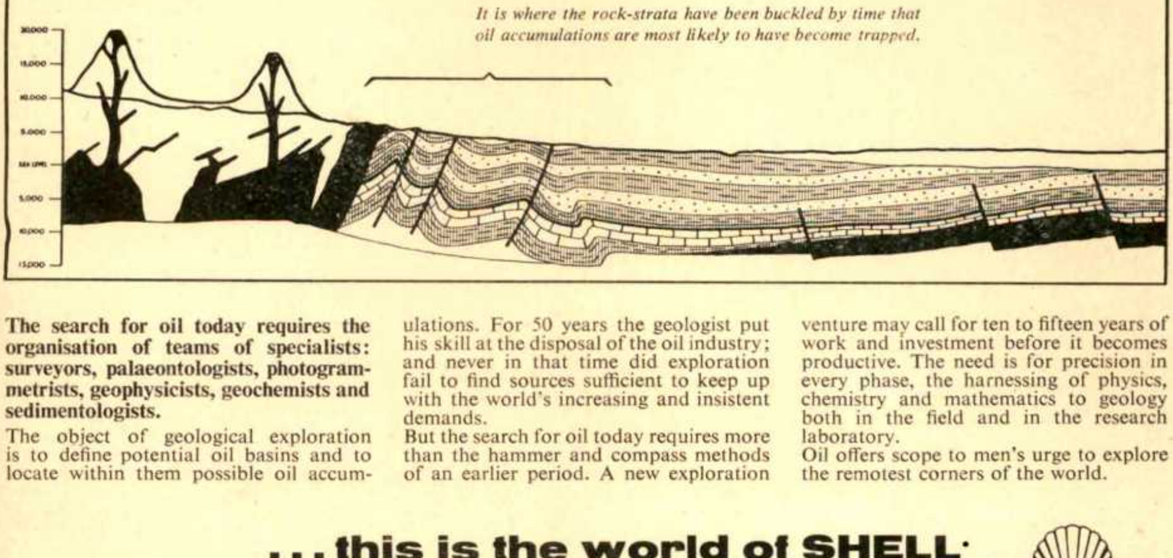

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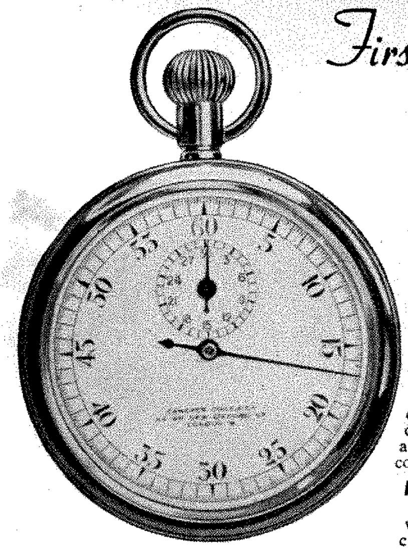

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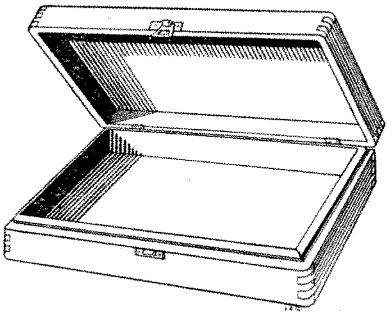

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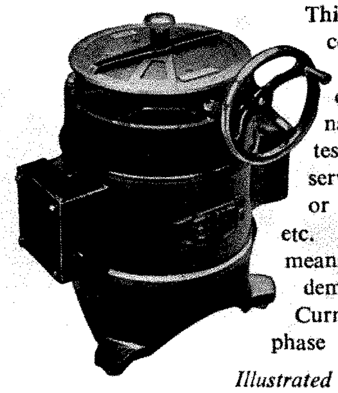

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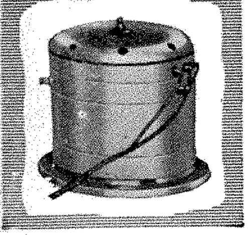

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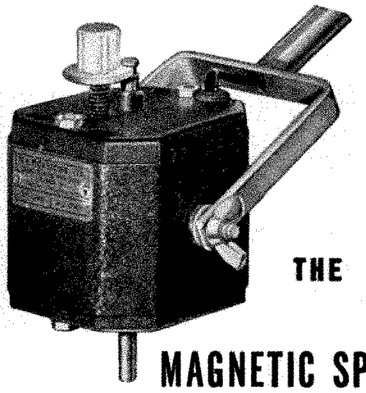

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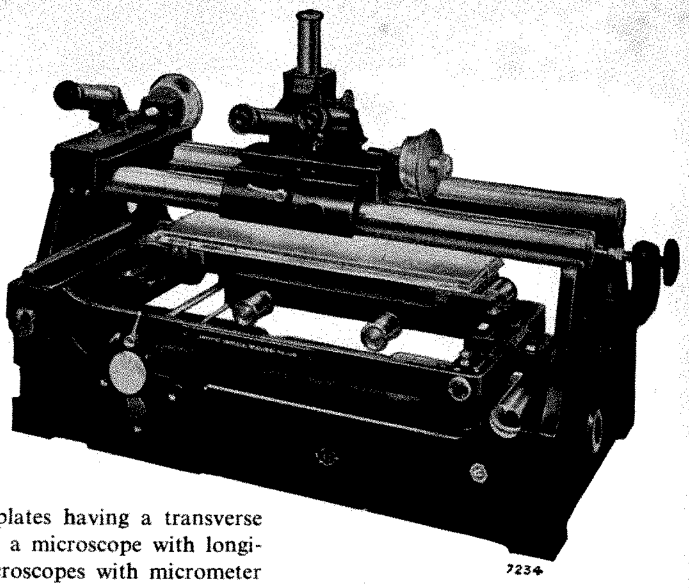

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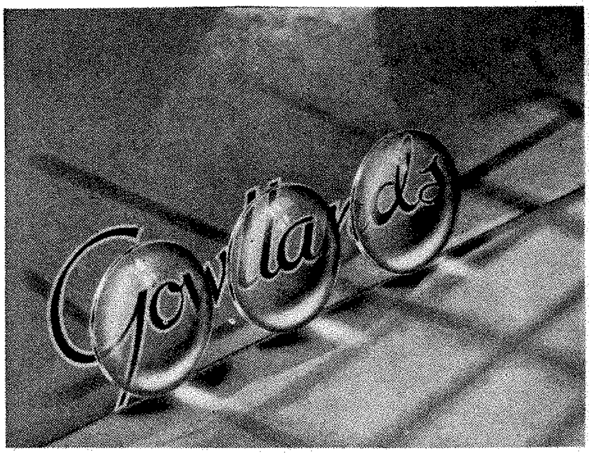

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Table 1. THE INDUCTION OF RESPIRATORY DEFICIENCY BY MANGANOUS SULPHATE

Culture	Concentration (per cent)	Standing culture 200 ml.				Shaken culture 200 ml.				Nitrogen-starvation medium. Standing cultures 50 ml. 24 hr.
		24 hr.		48 hr.		24 hr.		48 hr.		
		Per cent aer	Per cent variegated and sectored	Per cent aer	Per cent variegated and sectored	Per cent aer	Per cent variegated and sectored	Per cent aer	Per cent variegated and sectored	Per cent aer
14061 (Haploid)	0·06	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					2
	0·17	39	15	39	21	27	24	6	7	4
	0·33	56	26	64	21	25	18	4	4	3
F-2 (Diploid)	0·06	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					1
	0·17	52	10	77	6	8	17	10	6	1
	0·33	64	22	95	5	56	21	98	2	5
11294 × 11296 (Tetraploid)	0·66	< 1	0	< 1	0					< 1
	0·12	< 1	0	< 1	0					6
	0·17	69	11	95	3	33	23	14	4	8
	0·33	76	21	98	2	52	19	80	8	13

diagnostic plates was double-strength, except for glucose and agar, as compared with the medium containing the various agents. (The medium on the diagnostic plates was that ordinarily used in this laboratory, while the medium containing the salts was half-strength except for agar and glucose. Preliminary experiments had revealed that 'diluted' medium produced more deficient variants than full-strength medium.)

Treatments in liquid media were carried out in 20 ml. of medium in 50-ml. Erlenmeyer flasks, or 40 ml. of medium in 200-ml. flasks. Cells were sampled for inoculation on the diagnostic plates, usually after incubation for about 24 or 48 hr. at 30° C. Ammonium sulphate, peptone and yeast extract were omitted from some media, which were designated 'nitrogen-starvation' media.

Rapid surveys were achieved with gradient agar plates[6] containing the agent to be tested in the upper layer. Heavy suspensions of 1-day-old cultures were streaked on gradient plates and incubated for 48 hr. The streaks faded out gradually (instead of ending abruptly) after the range of confluent growth. In seeking to determine the effects produced on the Szybalski plates, cells were sampled from the intermediate region and spread on diagnostic plates after adequate dilutions.

Three strains, 14061 (haploid), *F*-2 (diploid) and 11294 × 11296 (tetraploid), were inoculated in liquid media supplemented with various concentrations of manganous sulphate and allowed to proliferate. When samples were diagnosed for respiration deficiency, red (sufficient), white (deficient) and sectored or variegated colonies appeared. The sectored colonies were red colonies with usually three or more white sectors; the variegated colonies had a dark red centre and white periphery, suggesting delayed response in the change from respiratory sufficiency to deficiency. Concentrations below 0·12 per cent were ineffective in inducing respiratory deficiency (Table 1). Nitrogen-starvation medium yielded very few deficiencies.

Manganous chloride was found to produce the same effect as manganous sulphate.

Manganous sulphate is only slightly toxic to yeasts. The survivors of the tetraploid culture (11294 × 11296) (spread on plates containing 0·17 and 0·33 per cent manganous sulphate) were 85 and 48 per cent, respectively. Colonies grown on manganese agar suspended in water and spread on diagnostic plates were found to contain approximately the same percentages of respiratory-deficient cells as similar cultures grown in liquid media containing manganese.

To test the possibility that respiratory-deficient cells may have a competitive advantage over respiratory-sufficient cells in medium containing manganous salts, cells were picked up by a micromanipulator from a 1-day-old tetraploid (11294 × 11296) culture in standard medium and transferred separately to standard and 0·17 per cent manganous sulphate agar and allowed to proliferate for 72 hr. Of twenty cells transferred to manganous sulphate agar, thirteen formed colonies. Samples from suspensions of those colonies contained 45–65 per cent respiratory-deficient cells. Eighteen colonies formed on normal agar (two out of twenty failed to grow) contained less than 1 per cent respiratory-deficient cells. It may be inferred that each colony started from a single respiratory-sufficient cell and produced respiratory-deficient cells at high frequencies during proliferation in the presence of manganous sulphate. The frequent occurrence of sectored and variegated colonies (which generally decrease with time) also supports the view that induction has occurred.

Growth of the respiratory-sufficient diploid (*F*–2) culture was followed in 50-ml. flasks in the presence and absence of manganous sulphate. A respiratory-

Table 2. PERCENTAGE OF RESPIRATORY-DEFICIENT COLONIES (AMONG THE SURVIVORS) AFTER GROWTH IN MEDIA CONTAINING COBALTOUS CHLORIDE, NICKELOUS CHLORIDE AND CUPRIC SULPHATE

Standing cultures in 50-ml. flasks. Sampled at 24 hr. *K* indicates no survivors

Concentration (per cent)	14061 (Haploid)	*N*560 (Haploid)	*N*579 (Haploid)	*F*-2 (Diploid)	11294 × 11296 (Tetraploid)
$CoCl_2.6H_2O$					
0·013	33	< 1	< 1	< 1	< 1
0·025	100	< 1	2	20	< 1
0·038	100	95	5	90	11
0·050	*K*	*K*	*K*	*K*	*K*
$NiCl_2.6H_2O$					
0·013	< 1			< 1	< 1
0·025	< 1			< 1	< 1
0·038	< 1			< 1	< 1
0·050	46			53	65
0·075	*K*			*K*	*K*
$CuSO_4.5H_2O$					
0·006	7	< 1	< 1	4	13
0·013	*K*	1	4	17	*K*
0·025		86	71	*K*	
0·038		*K*	*K*		

deficient culture derived from the same strain (by treatment with manganese) was tested in parallel. The respiratory-sufficient culture grew slightly better than the respiratory-deficient one in the absence of manganese. The respiratory-sufficient culture in the presence of manganese produced many deficient cells, but a large fraction of respiratory-sufficient cells persisted indicating that respiratory-deficient cells do not have an overwhelming relative advantage. The respiratory-deficient culture was slightly inhibited in the presence of manganese.

Cupric sulphate ($CuSO_4.5H_2O$), cobaltous chloride ($CoCl_2.6H_2O$) and nickelous chloride ($NiCl_2.6H_2O$) are more toxic than manganous salts, but sublethal concentrations led to the production of the respiratory-deficient cells (Table 2). The cultures differ markedly in sensitivity to copper, and the results suggest that more respiratory-deficient variants are produced by resistant cultures than by sensitive ones.

Sodium chloride, potassium chloride, lithium chloride and strontium nitrate are much less toxic than copper, cobalt and nickel. Growth of haploid culture 14061 and tetraploid 11294 × 11296 was suppressed by 5·8 per cent sodium chloride, 7·4 per cent potassium chloride and 0·25 per cent lithium chloride. Strontium nitrate up to 0·6 per cent did not inhibit growth (higher concentrations could not be tested because of the formation of a precipitate). Even at concentrations which suppressed growth most of the inoculum survived after two days. Samples from treated flask cultures did not show any increase (over controls) in the frequency of the respiratory-deficient cells.

The inhibitory concentrations of mercuric chloride, potassium dichromate and arsenic acid were, respectively, 0·005 per cent, 0·01 per cent, 0·05 per cent. No increase in the frequency of the respiratory-deficient cells (above controls) was detected either in liquid medium or on gradient plates. This may be because the high toxicity did not permit sufficient growth for the expression of the phenomenon. Cultures grown in the presence of arsenic acid produced many dwarf colonies but were all red under the triphenyl tetrazolium chloride-overlay.

Respiratory deficiency in yeast may be the result either of destruction or inactivation of a cytoplasmic granule or mutation of a gene. Ephrussi[1], Laskowski[2] and Yanagishima[3] have shown that this condition may be induced with high frequency during growth by different organic poisons. The inorganic ions manganese, copper, cobalt and nickel induce respiratory deficiency in yeasts with high frequency. The high frequency of induction and the relative independence of ploidy suggests that most of the respiratory deficiencies induced by these ions are due to the destruction or inactivation of cytoplasmic granules rather than to effects on the genome. The alkaline earths, sodium, potassium, lithium and strontium, seem incapable of inducing respiratory deficiency. Mercury and arsenic failed to reveal any increase in respiratory deficiency above controls, but this may be due to their extreme toxicity.

Manganous salts were very slightly toxic, but induced respiratory deficiency with great efficacy. Demerec[7] classified manganous salts as 'very mutagenic' because of their mutagenic (?) effect on *Escherichia coli*, but the effect of manganous salts on yeasts seems to be due almost exclusively to their effect on cytoplasmic granules rather than on the genome.

It is commonly said that most mutagens (meaning agents which cause gene mutation) are carcinogens, and it has been inferred that the problem of cancer is related in some way to the structure of the deoxyribonucleic acid. This inference rests on the assumption that gene mutation is an important factor in carcinogenesis. Many of the effects, however, which are ascribed to gene mutation may be due to the damage to the autonomous cytoplasmic granules, and such carcinogens as ultra-violet and X-rays have often been demonstrated to produce stable variations in the extra-chromosomal apparatus. Re-evaluation of ideas relating gene mutation to carcinogenesis may be in order.

This work was supported by the Illinois Division of the American Cancer Society.

Note added in proof. Caffeine at concentrations of 0·2 per cent was similarly found to be highly efficacious in the production of respiratory deficiency.

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DIRECT OBSERVATION OF DISLOCATIONS IN GRAPHITE

By Dr. ALEXANDER GRENALL

Atomics International, North American Aviation, Inc., Canoga Park, California

RECENT electron microscopy work has revealed the presence of dislocations in graphite. The nature of these dislocations and their movement within the structure of the crystals have been studied and recorded by means of motion pictures. Many of the features of dislocation arrangement and motion described by Hirsch, Horne, Whelan and Bollman for aluminium[1] and stainless steel[2] have been observed also in the case of graphite. Single dislocations occur within crystal grains, line up to form sub-grain boundaries, form dislocation networks (square and hexagonal cross-grids), and are spontaneously generated at crystal edges. Examples of sub-grain boundaries (small-angle misfit boundaries) formed from aligned single dislocations are shown at *A* and *B* in Figs. 2*a* and 2*b*. An example of cross-grid dislocation networks is exhibited in Fig. 1*a*. These photographs and the others to be discussed were taken from the motion picture sequences and have not been retouched.

Sub-grain boundaries and cross-grids have been observed to undergo modification under thermal stress. They move about and undergo rearrangement and in some cases disappear completely after a time. The pinning of sub-grain boundaries by an obstacle in the graphite structure has been observed and photographed. As the obstacle was encountered, the motion of a section of the aligned dislocations making up the sub-grain boundary was slowed and brought almost to a complete halt. This resulted in a bowing of the sub-grain boundary. The nature of the obstacle was not determined.

To illustrate the above description, comparison of Figs. 1*a* and 1*b*, which are taken from the same motion picture scene but over an interval of time, demonstrates the alteration and almost complete disappearance of the cross-grid dislocation network. Next, study of Figs. 2*a*, *b* and *c* shows how sub-grain boundary *A* moves across the crystal from its position at the left in Fig. 2*a* to an intermediate position in Fig. 2*b*, and finally in Fig. 2*c* occupies the place originally devoted to the dislocation array *B*. This sequence of pictures also demonstrates the pinning and bowing of dislocations around an obstacle. The dislocation array *B* is seen in Fig. 2*a* to have been pinned at point *C* by some unidentified obstacle, and bowing has occurred. In Fig. 2*b* the bowed section of *B* is seen to have passed the pinning point and broken up into individual dislocations, which travel at right angles to the original direction of motion. The final picture of the sequence, Fig. 2*c*, shows that

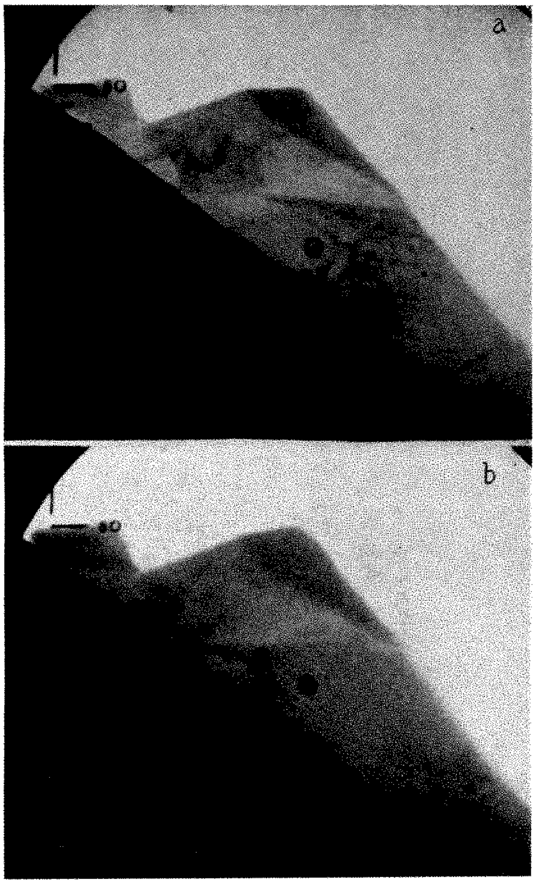

Fig. 1. Sequence of photographs taken from the motion picture film showing the alteration and almost complete disappearance of a hexagonal cross-grid dislocation network. (*a*) The network in early time under the microscope; (*b*) the same field at a later time. (Magnification of all illustrations is × 12,500; the distance between the black line markers is one micron)

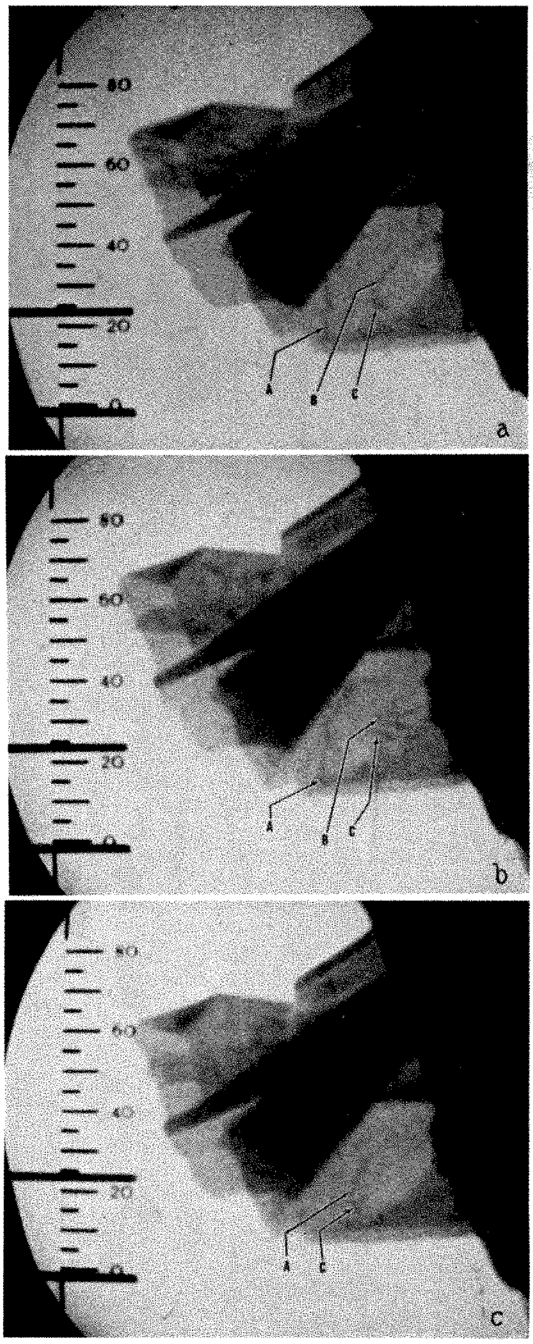

Fig. 2. A sequence taken directly from the motion pictures showing movement of aligned single dislocations forming the sub-grain boundary at *A* in (*a*) to an intermediate position in (*b*), to occupy finally the space originally devoted to dislocation array *B* in (*c*)

This sequence of photographs also demonstrates a pinning point at *C*. In (*a*), array *B* is pinned and bowed around an obstacle at *C*, while in (*b*) the bowed section has passed the pinning point by breaking up into individual dislocations, which travel at right angles to the original direction of motion; (*c*) shows that dislocation array *B* has disappeared by moving out of the crystal and array *A* has moved into this area, has encountered the same obstacle at *C* as array *B* did originally and, as a result, has begun to bow dislocation array *B* has disappeared by moving out of the crystal and dislocation array *A* has moved into this area, has encountered the same obstacle at *C* as array *B* did originally and as a result has begun to bow.

Dislocation motion can be classified as fast or slow. The fast motions consist of a rapid jerky motion, while the slow motions involve a more gradual drifting of the dislocations across a crystal grain. Under the electron microscope, the speed of motion of the black lines indicating the presence of dislocations appears to differ depending upon whether the area of strain is associated with a single dislocation or a network of dislocations. In addition, the speed of motion presumably is determined by whether glide or climb occurs. It appears that glide is characterized by rapid motion while climb results in a slow drifting motion.

Only a brief description of the techniques and findings is given here because it is intended to present these fully in a later publication. The observations were made at 80 kV. in a Norelco *EM* 100*B* electron microscope. The driving force for producing dislocation motion was supplied by the thermal stresses set up by the electron beam. Sample preparation was simple. Natural graphite crystals were placed between two glass microscope slides and sheared by sliding one plate over the other. This action was sufficient to produce small fragments of cold-worked material. These fragments were mounted on a 200-mesh copper specimen screen by rubbing the particles into the screen. The crystals lie on the basal plane, normal or nearly so to the direction of the electron beam. Here and there are thin sections permitting ready observation by transmission of the dislocations as well as other features of the graphite structure. The motion pictures were taken by photographing the fluorescent screen of the electron microscope, operated at 12,500 and 25,000 magnification, by means of a 16-mm. Bell and Howell 70*J* camera, Angénieux *f*/0·95 lens of 1 in. focal length using Tri-*X* film at 16 frames per sec.

---

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FURTHER INHERENT CHARACTERS OF PLANT SPECIES OF WETTER AND DRIER HABITATS

By Dr. M. L. R. PETTERSSON and G. E. J. GRAY
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NOT many centuries after the introduction of alphabetic script, Theophrastus[1] employed this handy medium to record how some species of plant were characteristically found in one kind of community and habitat and some in another. From anthropological evidence, we may presume that this kind of knowledge existed, and was used, by our food-gathering forebears, before even the inception of agriculture. The systematists of the nineteenth century, and the ecologists among others of the twentieth[2], have emphasized the point with a wealth of necessary and erudite observations. But in future years the question will progressively be asked, not where does a species grow, but why does it grow there ; the question of what inherent characters of the plant suit it to such and such an environment[3–6].

The answer must be in terms of comparative anatomy and comparative physiology, including the physiology of growth and development, as describing that genotypic variation among different species upon which ecological selection acts. The comparative ecological anatomy of the first half of the twentieth century[3,5] gives us important clues. But it is now realized that the differences seen in the transverse stem sections of, say, *Ranunculus acris* and *R. aquatilis*, each grown in their natural habitats, may contain large and unassessed components due to induced modification, and that the nature and magnitude of the inherent genotypic difference has, in most such cases, never yet been experimentally determined[7]. The same applies to many earlier observations in comparative physiology[3]. Fresh and more critical comparisons are required between individuals of ecologically contrasting species which have been reared in the same environment.

A useful method of reducing random variation, in such comparisons, is to compare a pair of species which are similar in general structure as well as in seasonal behaviour, such as two species of the same genus[7]. A recent communication[8] describes such an investigation of pairs of species in six genera. In each case, individual plants of an ecologically wetter-living species were reared together with plants of a related drier-living species in a common environment. So far, the behaviour of only one character has been reported ; but it is the present purpose to give a very condensed summary of the behaviour of twenty characters. It is expected that this type of investigation may soon become commoner, since it is both of fundamental importance and of agricultural utility. The pairs of species compared are given in Table 1.

Table 1. PAIRS OF ECOLOGICALLY CONTRASTED BRITISH SPECIES, WHICH ARE COMPARED AFTER BEING REARED IN A COMMON ENVIRONMENT

Genus	Wetter-living species *W*	Drier-living species *D*
Ranunculus	*R. flammula*	*R. bulbosus*
Hypericum	*H. tetrapterum*	*H. perforatum*
Primula	*P. vulgaris*	*P. veris*
Veronica	*V. beccabunga*	*V. chamaedrys*
Centaurea	*C. scabiosa*	*C. nemoralis*
Poa	*P. fluitans* = *Glyceria fluitans*	*P. annua*

Rather than list all the 240 numerical values, only the direction of the deviation need be given, as in Table 2. Taking in each case the value for the drier-living species as a basis, a plus sign indicates that the wetter-living species is found to have a higher value for the particular character ; a minus sign, that the wetter-living species has a lower value ; and a nought, that no difference is reported. Thus the signs are those of (W–D).

Table 2. INTRAGENERIC COMPARISONS, FOR TWENTY CHARACTERS, WITHIN PAIRS OF SPECIES IN SIX GENERA

A plus sign indicates that the wetter-living species of the pair has the higher numerical value for the character concerned. The differences considered are inherent genotypic differences, induced modification having been neutralized (ref. 9)

Characters compared intragenerically	*Ranunculus*	*Hypericum*	*Primula*	*Veronica*	*Centaurea*	*Poa*	Association between magnitude of character and wetness of natural habitat
Section 1. Characters of lamina							
(*a*) Fresh weight	−	−	+		+	+	
(*b*) Water weight	−	−	+		+	+	
(*c*) Dry weight	−	−	−		−	+	? − ve
(*d*) Thickness	+	−	+	+	+	+	? + ve
(*e*) Degree of development of transpiring surface	−	+	−	−	−	−	? − ve
(*f*) Number of cells, estimated	−	−	−		+	−	? − ve
Section 2. Characters of palisade cell							
(*g*) Volume, and weight	+	−	+	+	−	+	
(*h*) Water weight	+	−	+	+	−	+	
(*i*) Dry weight	+	−	+	+	−	+	
(*j*) Chromosome number (refs. 2, 10)	+	−	0	−	−	+	
Section 3. Characters of lamina, inflected							
(*k*) Fresh weight/chromosome number (C.N.)	−	+	+		+	+	? + ve
(*l*) Water weight/C.N.	−	+	+		+	+	? + ve
(*m*) Dry weight/C.N.	−	+	−		+	+	
(*n*) Thickness of lamina/C.N.$^{1/3}$	−	+	+	+	+	+	? + ve
(*o*) Cell number estimate/C.N.	−	+	−		+	−	
(*p*) Cell number estimate × C.N.	−	−	−		−	+	? − ve
Section 4. Character of lamina and cells							
(*q*) Dilation, being fresh weight/dry weight	+	+	+	+	+	+	Sig. + ve
Section 5. Characters of palisade cell, inflected							
(*r*) Volume, or weight/C.N.	+	+	+	+	+	+	Sig. + ve
(*s*) Water weight/C.N.	+	+	+	+	+	+	Sig. + ve
(*t*) Dry weight/C.N.	+	+	+	+	+	+	Sig. + ve

For a large number of inherent characters, as is of course to be expected, there is no consistent association reported between magnitude of character and humidity of natural habitat. These characters are clearly not, as such, strongly selected by ecological wetness and dryness. This group includes the characters *a*, *b*, *g*, *h*, *i*, *j*, *m* and *o* of Table 2. But these serve as a foil to those other characters, the magnitude of which is more critical for success in wetter or drier environments.

A second group of characters may be distinguished, where there is a preponderant but not invariable relationship. Thus, the wetter-living species of a pair usually, though not always, differs inherently by having: (*c*) less dry weight of lamina; (*d*) greater thickness of lamina; (*e*) a lower degree of development of transpiring surface; (*k*) a higher ratio of lamina fresh weight to cell chromosome number; (*l*) a higher ratio of lamina water content to cell chromosome number; (*n*) a higher ratio of lamina thickness to cube root of cell chromosome number; besides (*p*) a smaller total number of chromosomes in the lamina, as obtained by multiplying the estimate of number of lamina cells by the number of chromosomes in each cell; (*f*) often a smaller number of cells per lamina. With regard to (*e*), this result is in opposition to the views of Huber[11,3]; but his generalization does, of course, apply to the distinction between night-feeding succulent xerophytes and non-succulent mesophytes.

With a third group of characters (sections 4 and 5), the deviations are here found to be invariably in the same direction, which seems to reflect rigorous direct or indirect selection of these inherent characters by ecological wetness or dryness. Thus, in the six genera concerned, the wetter-living species has inherently: (*q*) greater dilation of the lamina and its constituent cells; while its palisade cells, which with regard to size are interspecifically proportional to the average leaf cells[12], have (*r*) greater cell volume per chromosome; (*s*) greater cell water content per chromosome; (*t*) greater cell dry weight per chromosome.

While Maximov[3] did give some experimental evidence that non-succulent species of drier places usually have an inherently higher vacuolar osmotic pressure[13], he did not, in our opinion, prove that they had inherently smaller cells—as he considered he had done[14]—since his chain of argument contains the weak link of Le Chatelier's theorem applied quite out of context. The present investigation shows that in one third of the genera studied the drier-living species has, in fact, the larger cells, cells sometimes of nearly double volume. The issue has been bedevilled by polyploidy. But thanks to the collateral progress of nuclear cytology[10,2], it can now be unscrambled. Thus, for the material here studied, we can at least definitely state that the drier-living species have inherently in their laminas (i) drier cells, and (ii) cells which have a smaller volume per chromosome.

Without dealing with the various other points which arise, a picture begins to emerge of the selection by ecological dryness of genotypes with the following characters: less dilate and usually thinner laminas, but which usually contain a greater dry weight, a greater number of cells and a greater total number of chromosomes; and less dilate cells, in which each chromosome is associated with a smaller amount of dry matter and water and a smaller cell volume—cells in which unit dry weight contains apparently a higher proportion of genes.

It is perhaps not inappropriate to find it reported that these species of intrinsically less-favourable habitats have cells which are relatively the better equipped with molecular-level 'machine-tools'; while in moister habitats other species, less heavily equipped, are able to displace them. On a rough analogy, the maintenance workshops and equipment which supported Sir Vivian Fuchs's crossing of Antarctica would be out of place in a walking tour along the Pennines.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

β-Globulin Variants in Man

USING starch-gel electrophoresis, Smithies has discovered several β-globulin patterns in human plasma. He refers to these as β*C*, β*BC*, β*CD* and β*D*[1,2]. β*C* is the type most commonly found, but β*BC* occurred in about 1 per cent of Canadians and β*CD* in about 4 per cent of American Negroes and even more frequently in Australian Aboriginals. The formation of the different β-globulins *B*, *C* and *D* appears to be genetically controlled and Smithies suggests that each may be determined by one of three allelic genes.

In a search for such β-globulin types we have recently encountered four unusual patterns. The starch-gel electrophoresis was carried out on plasmas to which hæmoglobin had been added to saturate the haptoglobins, using the discontinuous buffer system of Poulik[3]. Under these conditions the β-globulin region is clear of either the hæmoglobin – haptoglobin complexes or free hæmoglobin (Fig. 1) and it is possible to pick out unusual β patterns in one-dimensional separations. The unusual plasmas were further subjected to two-dimensional paper/starch-gel electrophoresis[4] to confirm the identification of the new components as β-globulins.

In a series of 153 Africans from Gambia we observed four individuals who had, besides β-globulin *C*, a slower moving β-globulin component which was present in about the same amounts as β-globulin *C*. In one of these individuals, however, the unusual β-globulin component had a distinctly slower mobility than that found in the other three. Thus two distinct β-globulin variants appeared to be present in this African population, and since it is probable that one of these corresponds to the β-globulin *D* of Smithies we will refer to them for the present as β-globulins D_1 and D_2 (Fig. 1).

In a series of 139 English people no example of phenotypes βCD_1 or βCD_2 was observed. However, two individuals were encountered with an unusual β-globulin component moving faster than β-globulin *C*. In both, the new component was present along with, and in about equal amounts to, β-globulin *C*. The mobility of the new fast-moving component was, however, different in the two individuals (Fig. 1). Since one of them probably corresponds to Smithies' β-globulin *B* we will refer to these two new components as β-globulins B_1 and B_2.

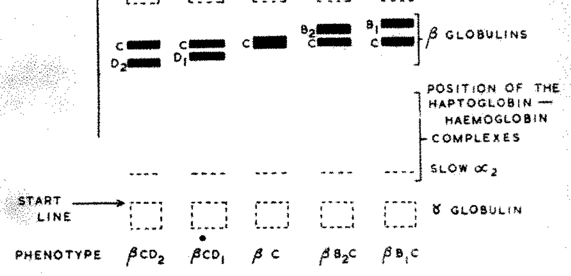

Fig. 1. Relative mobilities of β-globulin variants in human plasma. (Starch-gel electrophoresis with the discontinuous buffer system of Poulik)

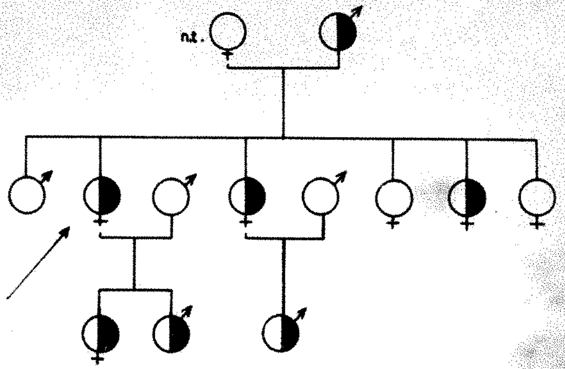

Fig. 2. Pedigree of family *W*. β-globulin phenotypes: ○, β*C*; ◑, βB_1C; *n.t.*, not tested

Among the relatives of the individual with phenotype βB_1C six further individuals were encountered with the same phenotype. The pedigree is shown in Fig. 2, and it seems reasonable to infer that the formation of β-globulin B_1 is genetically determined and that the individuals in this family with the βB_1C phenotype are heterozygous for the appropriate gene.

So far it has not been possible to carry out family studies on any of the other variants observed. However, these results, combined with those of Smithies[2], suggest that a whole series of genetically determined β-globulin variants can occur and the situation may well prove to be analogous to that found with respect to the genetically determined hæmoglobin variants which have been so extensively studied in recent years.

We would like to thank Dr. J. Humphries, who kindly put at our disposal the samples from the population in Gambia.

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High Resolution of Human Plasma Components by Starch Gel Electrophoresis

WITH one-dimensional starch gel electrophoresis, the following experimental procedure allows the separation of human plasma into a large number of components.

The gel is poured into 'Plexiglas' trays (internal dimensions 370 mm. × 50 mm. × 20 mm.). The sample (a mixture in equal parts of plasma and 30 per cent soluble starch in 0·025 *M* borate buffer) is applied in a slot, 40 mm. × 2 mm. Electrical connexion with the ends of the gel is obtained by means of thick filter paper ('Cofram' *MAB C* 3).

A potential of 450 V. is applied for 18 hr. at +4° C. After electrophoresis, the gels are fixed in

5 per cent acetic acid and stained with aqueous amido-black (amido-black 10 *B*, 1 gm.; 1 *M* acetic acid, 500 ml.; 0·1 *M* sodium acetate, 500 ml.). The gel is then washed with 5 per cent acetic acid.

The electrophoretic pattern obtained with a haptoglobin type 2 (*Hp* 2) human plasma is shown in Fig. 1; on the cathodic side of the slot, two γ-globulin zones; on the anodic side, from the slot towards the albumins, first are seen two zones, one being a β-lipoprotein (which stains with sudan black); then the $S\alpha_2$-globulin band, then nine strips between the $S\alpha_2$- and the βc-globulin, three of them being characteristic of *Hp* 2–1 and *Hp* 2–2 groups; then βc-globulin, one or two $F\alpha_2$-globulins, five strips between the fast α_2 and the albumin border and finally albumin.

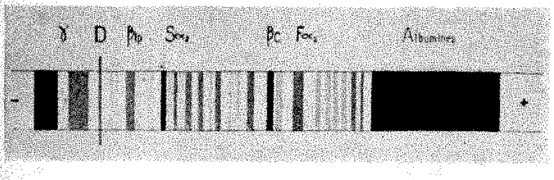

Fig. 1

The recent results obtained by Poulik and Smithies[1] with two-dimensional starch gel electrophoresis define the nature of the zones we have just described. We believe that among the five strips between the albumin and the fast α_2-globulins some correspond to the α_1-globulins (α_1A or α_1B).

The βc globulins are preceded by a zone which may be a β component (β*A* or β*B*).

Besides this large tray technique we have used a standard method involving smaller 'Plexiglas' trays (internal dimensions 234 mm. × 80 mm. × 6 mm.) for the study of different protein solutions. Two samples are applied in two slots (28 mm. × 2 mm.) and allowed to migrate simultaneously, side by side, in the same tray for 18 hr. with a 140 V. potential. Electrophoretic patterns under these conditions are similar to those obtained by Smithies[2]; however, the γ-globulin zone is distinctly divided into two components. In macroglobulinæmia an increase in the fast or the slow component can occur.

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A New Method for resolving Amino-acids by Metabolism of Bacteria on Benzoyl Derivatives of DL-Amino-acids

While engaged in the study of metabolism and hydrolysis by soil bacteria of benzoic acid derivatives, amino-acids, and acylated amino-acids[1–4], we noticed that soil bacteria *KT* 231 and *KT* 233 have the metabolic activity shown in Table 1. The constituents of the culture medium used in the experiments were as follows: NH_4Cl, 0·1 gm.; K_2HPO_4, 0·1 gm.; $MgSO_4.7H_2O$, 0·05 gm.; 1 per cent $CaCl_2.6H_2O$, 2 drops; 1 per cent $FeCl_3.6H_2O$, 1 drop; organic substance to be tested, 0·2 gm.; distilled water, 100 ml.; *p*H 7·4–7·6 (adjusted with 10 per cent sodium hydroxide).

Table 1

	KT 231	*KT* 233		*KT* 231	*KT* 233
Benzoic acid	+	+			
Dibenzoyl-DL-lysine	+	+	Benzoyl-DL-leucine	+	+
Dibenzoyl-DL-lysine (without NH_4Cl)	–	–	Benzoyl-DL-leucine (without NH_4Cl)	–	+
Dibenzoyl-D-lysine	–	–	Benzoyl-D-leucine	–	–
ε-N-Benzoyl-DL-lysine	–	–	DL-Leucine	–	+
Benzoyl-DL-phenylalanine	+	+	N-Benzoyl-DL-threonine	–	+
Benzoyl-DL-phenylalanine (without NH_4Cl)	–	+	N-Benzoyl-DL-threonine (without NH_4Cl)	–	–
Benzoyl-D-phenylalanine	–	–	N-Benzoyl-D-threonine	–	–
DL-Phenylalanine	–	+	DL-Threonine	–	–

+, Within four days at 25° C. there were luxuriant growths of bacteria on a culture medium with the particular organic compound as the source of carbon. This cultivation experiment was repeated three times in succession.

–, No visible growth of bacteria observed.

From the left column of Table 1, it is to be understood that *KT* 231 and *KT* 233 can utilize benzoic acid, which was produced from dibenzoyl-L-lysine by the action of their acylases, as the sole source of carbon. The ability of *KT* 231 to resolve dibenzoyl-DL-lysine was then tested as follows: *KT* 231 was grown at 25° C. in 100 ml. of the culture medium mentioned above containing 2·67 gm. of dibenzoyl-DL-lysine. After 3 days, the culture medium was adjusted to *p*H 4·5 with acetic acid, evaporated *in vacuo* to a small volume, acidified with dilute hydrochloric acid to *p*H 1·0, and extracted with ethyl acetate. From the aqueous layer, 0·80 gm. (85·0 per cent) of ε-N-benzoyl-L-lysine, m.p. 270–272° C. (decomp.), $[\alpha]^{20}_D = +19°$ was obtained. From the ethyl acetate layer, 1·08 gm. (81·5 per cent) of dibenzoyl-D-lysine, m.p. 145–146° C., $[\alpha]^{20}_D = +7·5°$ and 0·03 gm. (6·5 per cent) of benzoic acid, m.p. 118–120° C. were obtained.

In the same way, *KT* 231 metabolized benzoyl derivatives of DL-phenylalanine and DL-leucine to yield the following compounds respectively: L-phenylalanine, $[\alpha]^{18}_D = -35°$, benzoyl-D-phenylalanine, m.p. 139–140° C., $[\alpha]^{18}_D = -15°$ and L-leucine, $[\alpha]^{20}_D = +15°$, benzoyl-D-leucine, m.p. 103° C., $[\alpha]^{20}_D = +9·5°$. By the metabolism of *KT* 233, L-threonine, $[\alpha]^{20}_D = -28°$, and N-benzoyl-D-threonine, m.p. 145–146° C., $[\alpha]^{20}_D = -25°$, were obtained from *N*-benzoyl-DL-threonine in good yield.

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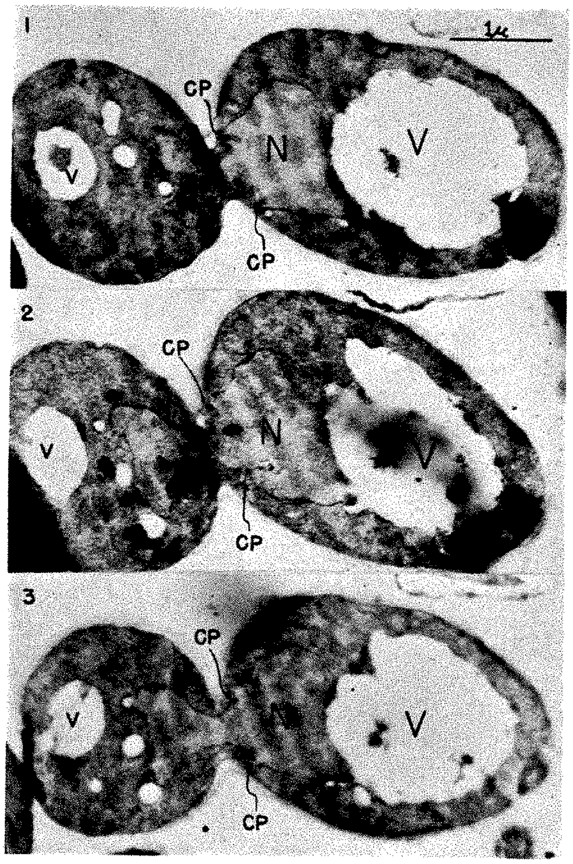
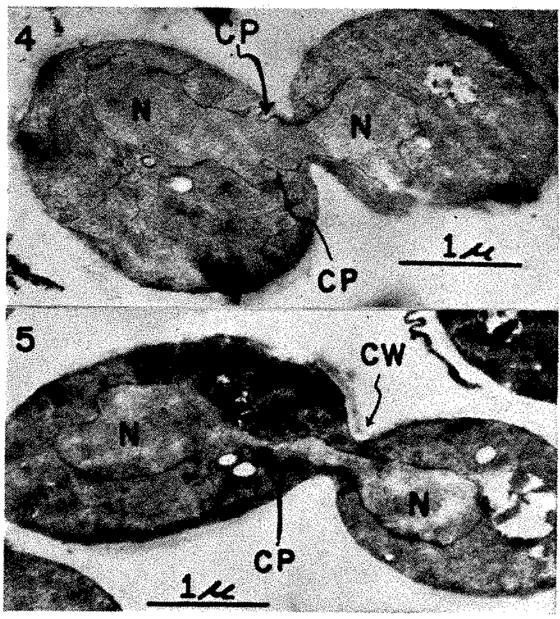
Nuclear Changes occurring during Bud-formation in *Saccharomyces cerevisiae* as revealed by Ultra-thin Sectioning

The lack of clarity prevailing among yeast cytologists as to the mode of budding in *Saccharomyces cerevisiae* tempted us to study this process by means of an improved ultra-thin sectioning technique. This technique has enabled us to observe nuclear behaviour during bud formation and subsequent division. Except for substitution of potassium permanganate for osmium tetroxide as the fixative, the method of preparing specimens for ultra-thin sections was exactly the same as previously reported[1,2]. A distillers yeast, *S. cerevisiae M*-1, was grown in a broth medium for several hours at 25° C. with aeration by means of vigorous shaking. The cells were collected by centrifugation and washed once with distilled water. The washed cells were then fixed in a 1·5 per cent aqueous solution of potassium permanganate at room temperature for 30 min. The time of fixation and concentration of permanganate were critical for preservation of internal cell structure. Explosion was minimized by prolonged treatment of the cells with cold partially polymerized *n*-butyl methacrylate. The sections were cut on a Porter–Blum microtome and observed in an *RCA* model *EMU-2b* electron microscope. Figs. 1, 2 and 3 show three parallel sections of a budding yeast cell. It is interesting that the conspicuous invagination of the dividing nucleus is situated a short distance away from the constricted cell wall of the bud. The difference in the planes of constriction between the nucleus and the cell wall seems to be a routine occurrence and is considered characteristic of vegetative division in *S. cerevisiae*. This suggests that there is some mechanism which regulates the constriction of the nucleus at this point other than the simple pressure of the constricting cell wall. Close observation of these figures reveals that the constriction starts at certain points rather than being initiated uniformly around the site of constriction. The presence of the nuclear membrane throughout vegetative nuclear division implies that typical mitosis in *S. cerevisiae*, at least in the strict sense of the word, is lacking. Chromosomal figures which have been observed in the nuclei of the cells of higher organisms[3-5] have not been detected in either the nuclear vesicle or on the nuclear membrane during any stage of the nuclear division. Figs. 4 and 5 demonstrate somewhat later stages of nuclear division during bud-formation.



Figs. 1–3. A budding yeast cell. *N*, nucleus; *CP*, constriction point; *V*, vacuole; *CW*, cell wall



Figs. 4–5. Budding yeast cells at a later stage. Key as in Figs. 1–3

From the observations made in this study, we conclude:

(1) The nuclear membrane of *Saccharomyces cerevisiae* does not disappear during vegetative division. This favours the view that division of the nucleus during budding does not occur by a typical mitotic process.

(2) The nucleus of *Saccharomyces cerevisiae* undergoes an autonomous constriction during bud formation. Constriction of the nucleus does not coincide with constriction of the cell wall, but always occurs a little inside the mother cell.

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Heinz Bodies in Extravasated Erythrocytes

In many cases of toxic anæmia refractile granules, generally known as Heinz bodies, are formed in the red blood cells. These inclusions may be identified by their intense basophilia when stained supravitally; after fixation with alcohol they lose this property and as a result are not usually seen in Romanowsky-stained blood films. In these anæmias there is an associated fragmentation and distortion of the red blood cells.

A similar type of fragmentation and distortion of the red cells is sometimes seen in hæmothorax fluids, and this led us to examine the red cells by supravital staining with methyl violet. By this means Heinz bodies were demonstrated in the majority of serous and cystic fluids, and sometimes in bloodstained cerebrospinal fluid as well.

The inclusions show similar features to those of Heinz bodies formed in the circulating blood. They may be seen as refractile particles in unstained wet preparations and rapidly assume a dark purple-black colour when stained supravitally with 0·5 per cent methyl violet in normal saline. They vary in size from the minutest of dots to structures 3μ in diameter, and irregularly shaped forms may be seen as well as more rounded inclusions. An affected red cell may contain a single inclusion or a number (Fig. 1).

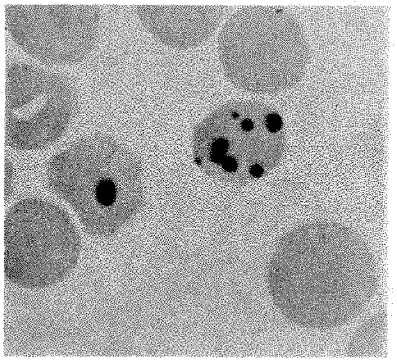

Fig. 1. Heinz bodies in erythrocytes in pleural fluid

The affected red cells may be otherwise normal in appearance, although often the inclusions are also found in distorted or spherocytic cells. In some specimens the red cells show a greater variety of appearances than red cells from the circulating blood in Heinz body anæmia.

Table 1 classifies 121 specimens from 100 patients, grading the extent of Heinz body formation in three categories.

In 15 cases more than one specimen was examined over a period of time. In six cases the proportion of cells containing Heinz bodies rose; for example, in a case of hæmothorax following mitral valvotomy there were 1·5 per cent 9 days after operation, less than 0·5 per cent at 24 days, 2 per cent at 28 days and 10 per cent 37 days following the operation. In one case an increase was later followed by a decrease; in seven cases no appreciable difference in the proportion of Heinz body containing cells was observed; and in two cases only a decrease was found.

Table 1

	Percentage of red cells containing Heinz bodies			
	>5·0	0·5–5·0	< 0·5	Total
Pleural and peritoneal fluids	19	40	32	91
Cysts, hydrocœles, joints and bullæ	2	5	4	11
Hæmatomas	1	6	1	8
Cerebrospinal fluid	4	6	1	11
Total	26	57	38	121

We consider that the finding of red cells containing Heinz bodies in so high a proportion of fluids examined indicates that this is a normal step in the breakdown of red cells which have been shed into the body cavities. In old collections of blood the affected corpuscles are very numerous. For example, in a subdural hæmatoma of 3 weeks standing 70 per cent of the red cells were affected; in a pseudomucinous ovarian cyst 85 per cent, and in a dental cyst of the maxilla 100 per cent of the red cells contained Heinz bodies. In such cases as these the cells show complete loss of hæmoglobin and the inclusions become fixed to the distorted cell membrane. However, in serous cavities from which extravasated red cells are usually absorbed rapidly, such as the pleural and peritoneal spaces, cells containing Heinz bodies are often very scarce.

Although there are a number of reports[1-4] that similar inclusions are formed when red blood cells are incubated *in vitro* under sterile conditions, we have found only one case report in the literature of this century[5], in which Heinz bodies were noted in extravasated red cells *in vivo*. The phenomenon was, however, known to Virchow, and is described in the first volume of his *Archives*[6], but seems to have been since forgotten. Experiments by one of us (R. S. S.) are now in progress to follow the process of Heinz body formation in shed blood, and the results will be published later.

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Antibiotic Substances from Yeast

It was suggested[1] that the micro-organism-inhibiting properties of material from baker's yeast reported by us[2] might lie in a mixture of fatty acids. Although we had found that fatty acids from yeast could inhibit the respiratory metabolism of yeast and tissues[3] we believed that other types of substances might be involved.

The following preparative procedure was finally used. Twenty-five pounds of baker's yeast were extracted with 95 per cent ethanol under reflux for 5 hr. The extract was taken to dryness *in vacuo* and 100 ml. of water were added. After filtration, the aqueous filtrate was acidified to pH 2 with 0·1 N hydrochloric acid and extracted with ether. The ether was removed and the residue was dissolved in water and adjusted to *p*H 6. The aqueous solution was extracted with ether and the ether discarded. The aqueous solution was adjusted to *p*H 4 and again extracted with ether. The ether solution was concentrated and placed in one strip on Whatman No. 3 *MM* paper. The ascending chromatogram was developed with water/pyridine/ethyl acetate (400 : 180 : 400). After spraying with ammonium hydroxide, a strip containing material which fluoresced yellow under ultra-violet light could be cut out. The material was eluted with ethanol and the concentrated eluate was chromatographed by the descending technique, using ethanol/water/ammonium hydroxide (80 : 15 : 5) as the solvent. After spraying the paper with ammonium hydroxide, ultra-violet light revealed two strips, *Y*1 with R_F 0·5, and *Y*2 with R_F 0·7. Each was eluted separately with ethanol and the concentrated eluates were separately chromatographed by the ascending technique in water/pyridine/ethyl acetate. Both substances, in yields of about 30 mgm., were colourless, soluble in warm ethanol, and chromatographically pure. They could not be crystallized. They did not give colour reactions on chromatograms with ninhydrin, diazotized sulphanilic acid, Ehrlich's reagent, or cyanogen bromide. Attempts to obtain derivatives with 2,4-dinitrofluorobenzene and picric acid failed.

After hydrolysis with hydrochloric acid, *Y*1, in two-dimensional chromatograms with the solvents phenol saturated with a solution of 6·3 per cent sodium citrate and 3·7 per cent potassium dihydrogen phosphate[4], and butanol/acetic acid/water (4 : 1 : 1)[5], revealed leucine, valine, alanine, glutamic acid and glycine. *Y*2 gave the same amino-acids and, in addition, γ-aminobutyric acid.

Paper electrophoresis in phosphate buffers at *p*H's of 2, 4, 7 and 12 in all cases resulted in migration towards the anode, migration being most rapid at *p*H's 2 and 12. *Y*1 moved faster than *Y*2.

*Y*1 in acetone gave only a low ultra-violet cut-off. *Y*2 had an absorption peak at 255 mμ. γ-Aminobutyric acid gave only end absorption, but after standing in 2·5 per cent concentration in 0·1 per cent hydrochloric acid for a week slight absorption developed at 270 mμ. Infra-red absorption spectra of films on potassium bromide showed both compounds to absorb at approximately 3·0μ, 3·4μ, 5·95μ, 6·1μ (*Y*1), or 6·2μ (*Y*2), and 6·9–7·0μ; *Y*2 also had slight absorption at 8·0μ.

Antibacterial activity of all preliminary fractions as well as of *Y*1 and *Y*2 was determined *in vitro* against *Micrococcus pyogenes*, var. *aureus* by the filter disk method. Some of the fractions were also assayed against the moulds *Aspergillus niger* and *Penicillium glaucum*, and found to be effective. *Y*1, in a concentration of 1 mgm. per disk, produced a 1 cm. zone of complete inhibition of *M. pyogenes* in 24 hr. *Y*2, in a concentration of 0·5 mgm. per disk, gave a similar inhibition. γ-Aminobutyric acid has been shown to be inactive against the organism[6].

The compounds appear to be peptides, and since no free amino-groups have been detected, possibly cyclic peptides. *Y*1, somewhat more electronegative than *Y*2, seems to differ from *Y*2 only in the absence of γ-aminobutyric acid. γ-Aminobutyric acid has been isolated from yeast extract in the free state and has been considered to be a degradative product[5]. Our results suggest but do not prove that the acid may be a constituent of a peptide. Structural considerations obviously will depend upon future analytical studies.

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Recombination Ability of *Escherichia coli* *K*-12 Protoplasts

SINCE Repaske's[1] and Lederberg's[2] discoveries, protoplasts of *Escherichia coli* have formed useful material for biosynthetic and genetic studies, for example, in *T*-2 phage multiplication[3,4], in rehabilitation of a deficient mutant[5] and, more recently, in recombination behaviour[6]. During the past two years great advances have been made in our understanding of genetic recombination in *E. coli*, especially through the finding that genetic material is transferred from *F*+ donor into *F*− recipient cells[7-9]. In these situations, genetic recombination between *E. coli* protoplasts was attempted in order to obtain further information on the properties of protoplasts and the process of genetic recombination.

Cells of *E. coli* *K*-12 58–161 *F*+ in the stage of logarithmic growth were protoplasted with 100 μgm./ml. lysozyme and 0·3 mgm./ml. ethylenediamine tetraacetic acid (versene) in a solution of 30 m*M* *tris* buffer and 0·6 *M* sucrose at *p*H 7·8. Protoplasts of *E. coli* were suspended in phosphate buffer (*p*H 7·2) supplemented with 20 μ*M* glucose and 200 μgm./ml. sodium aspartate with and without stabilizer. In the former solution protoplasts were well stabilized (experiment 1) and in the latter they were osmotically shocked and a viscous lysate was obtained to which the same amount of stabilizer was added (experiment 2). The controls were unprotoplasted cells handled identically except for the omission of lysozyme and versene (experiment 3 vs. experiment 1 and experiment 4 vs. experiment 2). These four preparations were mated for 2 hr. at 37° C. with intact *Y*-70 *F* − recipient cells requiring threonine, leucine and thiamine) and then plated on *EMS* medium. Various kinds of stabilizers were tested to ascertain whether they could support the protoplasts and their recombination. It was shown that 0·6 *M* sucrose was the most appropriate stabilizer for this purpose ; others, such as disodium hydrogen phosphate and sodium and potassium chlorides, sodium succinate, etc., inhibited recombination in spite of their efficient stabilizing effect. Table 1 shows a typical experiment illustrating the formation of recombinants in phosphate buffer

Table 1. RECOMBINANT FORMATION FROM *Y*-70 *F*− CELLS MATED WITH 58-161 *F*+ PROTOPLAST AND LYSATE PREPARATIONS

Exp.	*F*−	× *F*+	No. of recombinants
1	Unprotoplasted	protoplasted	109
2	Unprotoplasted	protoplasted, lysed	42
3	Unprotoplasted	unprotoplasted	179
4	Unprotoplasted	unprotoplasted, lysed	190

Table 2. DIFFERENTIAL CENTRIFUGATION OF PROTOPLASTED AND UNPROTOPLASTED CELLS

Speed in r.p.m. Percentage recovery of protoplast		1,000 94	2,000 5	3,000 1
			No. of recombinants*	
F− ×	*F*+			
Unprotoplasted	protoplasted	128 (1·4 × 10⁶)	16 (3·4 × 10⁶)	0 (1·0 × 10⁶)
Unprotoplasted	protoplasted, lysed	16 (1·0 × 10⁶)	16 (3·2 × 10⁶)	0 (1·0 × 10⁶)
Unprotoplasted	unprotoplasted	92 (1·1 × 10⁸)	40 (3·1 × 10⁸)	12 (2·4 × 10⁸)

* Figures in parentheses indicate the intact bacterial count per ml. remaining in each fraction.

stabilized with sucrose and supplemented with glucose and aspartate.

This suggested that some but not all of the recombinants were formed at the protoplast level, because the number of recombinants was decreased if the protoplasts were lysed by osmotic shock as in experiment 2. The difference between experiments 1 and 2 was smaller than the initial expectation, but this may be due in part to the slight increase between experiments 3 and 4. In every experiment, of course, intact cells which had not been affected by lysozyme remained in the protoplast and lysate preparations and participated to some extent in the formation of recombinants. However, the number of recombinants which appeared were much in excess of the number expected to arise from residual intact cells at the normal recombination rate ($1 \cdot 4 \times 10^{-8}$ in phosphate buffer). This remains, however, to be studied in detail.

The implications of these experiments were supported by certain differences in behaviour during centrifugation between protoplasted and unprotoplasted cells. Most of the protoplasts formed were easily collected by low-speed centrifugation. About 94 per cent of the protoplasts were deposited in 10 min. at 1,000 r.p.m., and when the supernatant from this first centrifugation was spun again at 2,000 r.p.m., a further 4 per cent of the protoplasts were recovered in the deposit. Each of these was mated directly or after being lysed by dilution with the unprotoplasted *F*− cells as in the method described earlier.

This experiment showed that the fraction which yields most of the recombinants coincides with that in which most of the protoplasts were recovered.

The reciprocal cross was made in which *Y*-70 *F*− cells were protoplasted and mated with intact 58–161 *F*+ cells in a similar procedure to that described above.

If the recipient *F*− cells were protoplasted and lost their capacity for further cell division, recombinant formation would have been inhibited completely. In fact, however (Table 3), a number of recombinants appeared. If all the *F*− protoplasts were lysed, they presumably could not have acted as recipient cells and yielded recombinants. The 32 recombinants, therefore, must have arisen from mating of the unprotoplasted *F*+ cells with residual *F*− cells, and their recombination-rates were increased by the liberation of a nutrient material from the products of lysing protoplasts.

Table 3. RECOMBINANT FORMATION FROM 58-161 *F*+ CELL MATED WITH *Y*-70 *F*− PROTOPLAST AND LYSATE PREPARATIONS

Exp.	*F*− ×	*F*+	No. of recombinants
5	Protoplasted	unprotoplasted	42
6	Protoplasted, lysed	unprotoplasted	32
7	Unprotoplasted	unprotoplasted	115
8	Unprotoplasted, lysed	unprotoplasted	120

Table 4. RECOMBINANT FORMATION FROM PROTOPLAST AND LYSATE PREPARATIONS

Exp.	*F*− ×	*F*+	No. of recombinants
9	Protoplasted	protoplasted	112
10	Protoplasted	protoplasted, lysed	65
11	Protoplasted, lysed	protoplasted	9
12	Protoplasted, lysed	protoplasted, lysed	4

Further support was obtained from alternative crosses in which both *F*+ and *F*− protoplasts were mated directly (experiment 9), either *F*+ or *F*− protoplasts were shocked and mated with *F*− or *F*+ protoplasts respectively (experiments 10 and 11), and both were shocked and mated together (experiment 12).

These results indicate the one-way transfer of genetic material from *F*+ to *F*− cells; the appropriate compatibility-type of donor and recipient is required even in the subcellular level. But the question remains whether *F*− protoplasts which could not divide further by themselves acquired the ability to revert and to form normal colonies after mating with *F*+.

These results with *E. coli* protoplasts illustrate the possibility of a new approach to the study on the mechanism of bacterial recombination and transformation.

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Effects of Flavin Monosulphate and Flavin Adenine Dinucleotide on the Electroencephalogram

FLAVIN MONOSULPHATE (riboflavin-5′-monosulphate) has been found to inhibit D-amino-acid oxidase in competition with flavin adenine dinucleotide[1]. On the other hand, it was supposed that flavin adenine dinucleotide might have some important role in the brain since it reversed the inhibitory action of chlorpromazine on the oxidation of amino-acids by a homogenate of the diencephalon part of the brain[2]. Taking these results into consideration, the effects of flavin monosulphate and flavin adenine dinucleotide on the function of the brain were examined by electroencephalography.

Flavin monosulphate was synthesized by sulphonation of riboflavin dissolved in pyridine using chlorosulphonic acid at 40° C., in dry conditions. The flavin monosulphate was purified by powdered

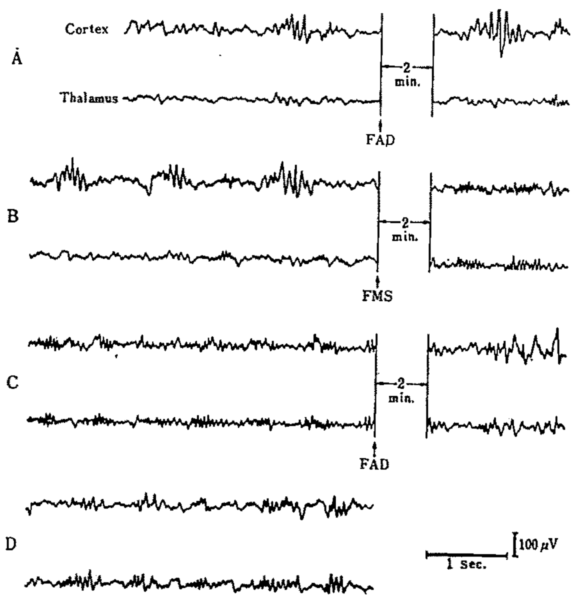

Fig. 1. Effects of the successive injection of flavin adenine dinucleotide and flavin monosulphate on the electroencephalogram. (*A*) Corticogram and depth electroencephalogram from the thalamus before and after the administration of flavin adenine dinucleotide; (*B*) the effect of the administration of flavin monosulphate on the continued electroencephalogram of (*A*); (*C*) the effect of the second administration of flavin adenine dinucleotide on the continued electroencephalogram of (*B*); (*D*) continued electroencephalogram of (*C*)

cellulose chromatography, and finally the calcium salt of flavin monosulphate was obtained as yellow crystals[3]. Flavin adenine dinucleotide was prepared by the method of Yagi *et al.*[4]. Its purity was more than 92 per cent, and other flavins, nucleic acids or metals were not present. Each flavin compound was used as an aqueous solution containing $0 \cdot 25 \times 10^{-6}$ mol./ml.

A guinea pig was narcotized by the intra-abdominal injection of urethane. After craniotomy, two kinds of electrode were placed on the brain; one was on the surface of the cerebral cortex to record the corticogram, and the other was put into the thalamic region to record the depth electroencephalogram. The exact position of the depth electrode was checked by histological examination of the brain after the experiment. The reference electrode was put on the frontal area of the cranium, and the monopolar leads were taken between the reference electrode and the cortex or the thalamic region. For recording, a Grass Model III *D* electroencephalograph was used. When a stable electroencephalogram was obtained, 2 ml. of an aqueous solution of flavin monosulphate or flavin adenine dinucleotide ($1 \cdot 0 \times 10^{-6}$ mol./kgm. of animal) were injected intra-abdominally, and the changes in the electroencephalogram were observed.

After the injection of flavin adenine dinucleotide, the voltage increased in both electroencephalograms. The characteristic change was observed in the corticogram: a slow wave of high voltage in spindle form appeared periodically. On the other hand, after the injection of flavin monosulphate, fast activity of 20–25 c./s. was observed in both electroencephalograms, and the voltage did not increase, but slightly decreased.

The changes in both electroencephalograms after the successive administration of flavin adenine dinucleotide and flavin monosulphate are shown in Fig. 1. By the administration of flavin adenine dinucleotide, the changes mentioned above were observed as shown in Fig. 1 *A*, *B*. 15 min. after the injection, flavin monosulphate was injected, and the remarkable fast activity appeared in both electroencephalograms (Fig. 1 *B*, *C*). Then, 15 min. later, flavin adenine dinucleotide was injected again, and the voltage increased in each electroencephalogram and the frequency decreased (Fig. 1 *C*, *D*). From these results, it seems that flavin adenine dinucleotide and flavin monosulphate have opposite effects on the electroencephalogram to each other.

The effects of free riboflavin and adenosine monophosphate were also examined. Free riboflavin did not cause any change on the electroencephalogram. Adenosine monophosphate had a tendency to increase the voltage, but this change was less than that due to flavin adenine dinucleotide, and the spindle forms were not observed. The effect of calcium ions at a concentration equivalent to that in the aqueous solution of flavin monosulphate calcium salt was also examined, and the result showed no characteristic change.

It is interesting to see that the antagonistic action of two flavin compounds found in the pure enzyme system was also observed in functional phenomena such as the electroencephalogram.

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Activation of an Ascorbic Acid Concentrating Mechanism by Some Corticosteroids *in vitro*

A RELATION between the actions of ascorbic acid and certain corticosteroids has often been indicated[1]. Since considerable evidence has accumulated that steroid hormones may act by altering the permeability of the cell membrane to a given compound[2] this relationship may be the result of changes in the permeability of certain cellular membranes to ascorbic acid as a result of the action of certain corticosteroid hormones.

To examine this possibility the following experiment was carried out. Six male rats of the Long–Evans strain weighing 250–300 gm. were maintained on a 60 per cent glucose diet[3] for three days. They were then killed, their livers rapidly removed and slices $0 \cdot 5$ mm. thick were prepared. 1 gm. of slices was incubated in 5 ml. of Krebs–Henseleit bicarbonate buffer[4] (*p*H $7 \cdot 3$–$7 \cdot 4$) containing 200 mgm. per cent glucose with or without 25 mgm. per cent of the hormone indicated. Complete solubility was not obtained with either hormone, but they were kept

Table 1

Animal	Flask	Hormone	Ascorbic acid diffusing into media per gm. of liver (μgm.)	Decreased diffusion of ascorbic acid per gm. of liver (μgm.)*
1	1*A*	None	202	25
	1*B*	Hydrocortisone	177	
2	2*A*	None	177	34
	2*B*	Hydrocortisone	143	
3	3*A*	None	178	25
	3*B*	Hydrocortisone	153	
4	4*A*	None	280	74
	4*B*	Cortisone	206	
	5*A*	None	214	47
	5*B*	Cortisone	167	
5	6*A*	None	260	77
	6*B*	Cortisone	183	
	7*A*	None	189	17
	7*B*	Cortisone	172	
6	8*A*	None	216	37
	8*B*	Cortisone	179	
	9*A*	None	191	41
	9*B*	Cortisone	150	

* Standard deviation = ± 20

well dispersed while being pipetted. In all cases the liver slices in the flasks of a given number were prepared from the same liver lobe of the animal. At the end of 3 hr. incubation at 37° in an atmosphere of 95 per cent oxygen and 5 per cent carbon dioxide, a 3 ml. sample of the medium was removed and the protein precipitated with 12 ml. of 5 per cent trichloracetic acid. The ascorbic acid was then determined in duplicate for each flask by the method of Roe and Kuether[5]. Tests with standard amounts of ascorbic acid in the presence and absence of cortisone indicated that the hormone had no effect on the ascorbic acid determination. The results are shown in Table 1 and indicate a decreased diffusion of ascorbic acid in the presence of either hormone.

A possible explanation for this phenomenon is the activation of a mechanism for concentrating ascorbic acid by the hormones, either at the cell membrane or at some intracellular site.

Since there is evidence that ascorbic acid is essential to the animal cell for the maintenance of ferrous ions and thus for the continued operation of the citric acid cycle (aconitase) and other reactions dependent on ferrous ions[6], many of the metabolic roles of these corticosteroids may be exerted indirectly by increasing the intracellular concentration of ascorbic acid with the resultant activation of these metabolic reactions based on ferrous ions. A possible permeability barrier to ferrous ions or ascorbic acid or both at the mitochondrial membrane has been postulated[6]. The existence of such a barrier would necessitate an active transport mechanism.

Furthermore, there is evidence that a progressive increase in the production of corticosteroids occurs with increasing ascorbic acid deficiency in guinea pigs[7]. Hence the proposed mechanism may be involved in a homœostasis for the maintenance of optimal intracellular ascorbic acid and the continued operation of fundamental *in situ* cellular reactions dependent on ascorbic acid.

The above mechanism may also play a part in the activation reactions yielding energy associated with adaptation to stress. During stress tissues require greater amounts of ascorbic acid[1] and the increased secretion of corticosteroids that occurs during stress[1] may be a response that is essential to the transfer of this increased ascorbic acid to the intracellular sites where its actions occur.

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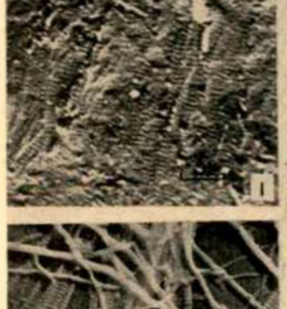
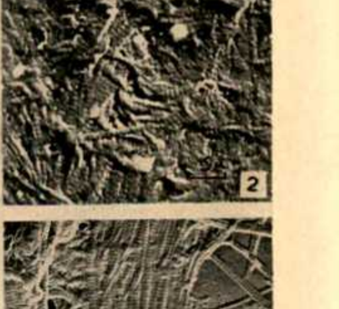
Collagen in Human Cementum as shown by Electron Microscopy

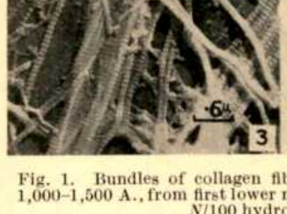
ELECTRON microscopy has been used extensively in the study of collagen in skin, tendon and cartilage. Its presence in bone has also been shown by several workers, including Huber and Rouiller[1] and Randall *et al.*[2]. Ascenzi[3], in addition to his own observations, discusses critically the literature on the structure of bone as demonstrated by electron-microscope techniques.

Examination of cementum matrix with the light microscope, using decalcified preparations selectively stained and ground sections of teeth, suggests that it contains collagenous fibres. In view of the close resemblance of cementum to bone as a calcified connective tissue, this investigation was undertaken to ascertain whether collagen fibrils could be demonstrated in human cementum using electron micrography.

Molar teeth extracted from young adults with no clinical disease of the cementum were washed in normal saline and then fixed in formalin. The teeth were bisected in the mesio-distal plane and the interior surface of the inner half polished and etched with *N*/100 hydrochloric acid. The structure of







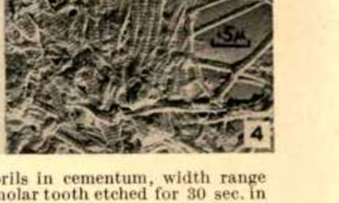


Fig. 1. Bundles of collagen fibrils in cementum, width range 1,000–1,500 A., from first lower molar tooth etched for 30 sec. in *N*/100 hydrochloric acid

Fig. 2. Interlacing collagen fibrils in cementum, width range 300–850 A., from first lower molar tooth, etched for 30 sec. in *N*/100 hydrochloric acid

Fig. 3. Shadowed teased preparation of tendo-calcaneus

Fig. 4. Shadowed carbon replica of tendo-calcaneus

cementum from each of the roots was examined by electron microscopy using gold-palladium pre-shadowed negative carbon replicas taken from the prepared surface.

In all the specimens examined fibrils exhibiting the characteristic 640 A. periodicity of collagen were observed. Broad bundles of fibrils (Fig. 1) having a width in the range 1000–1500 A. were observed. Interlacing fibrils (Fig. 2) were also seen throughout the cementum matrix with a width of 300–850 A.

Fig. 3 shows a shadowed teased preparation and Fig. 4 illustrates a shadowed carbon replica of collagen from the tendo-calcaneus.

The periodicity of the fibrils found in the cementum is 640 A., being the same as that of the collagen from the tendo-calcaneus.

All the material used and illustrated was obtained from women in the age group 20–22 years.

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An Abnormal Hæmoglobin in a Chinese : Hæmoglobin *G*

It has been known for many years that thalassæmia exists among the Chinese. Hæmoglobin *H* was discovered in a Chinese family[1] and has since been seen repeatedly in other Chinese families[2,3]. Thus in Singapore, over a period of fifteen months, 15 unrelated Chinese patients with anæmia were examples of hæmoglobin *H* disease. Another hæmoglobin, *Q*, has so far been observed only once in a Chinese family[4]. Of the other hæmoglobin variants, *E* has occasionally been noticed in Chinese. However, this is a rare finding, and the frequency cannot be compared with that observed in the neighbouring Burmese or Siamese, and certain Malayan, Cambodian and Indonesian communities. Hæmoglobins *S*, *C* and *D*, which are present at some frequency in certain non-Mongoloid populations, have so far never been described in Chinese, neither have been the rarer hæmoglobins *I*, *K*, *L*, *M*, *N*, *O* and *P*.

We have examined several thousand Chinese blood samples, about 5,000 in Singapore (F. V.) and about 500 in London (H. L. in collaboration with R. Bhagvan Singh, Medical Research Institute, Kuala Lumpur, and G. L. Robinson, Seamen's Hospital, Greenwich). Among these, two examples of hæmoglobin *J* were seen[5]. We are now able to record the finding of hæmoglobin *G* in a Chinese woman. The observation was made in the course of a survey of bloods from pregnant women sent for Wassermann tests to the Pathology Department, General Hospital, Singapore. The hæmoglobin of patient 'C3565' resolved on paper electrophoresis at alkaline *p*H into two components, one with the mobility of hæmoglobin *A* (65 per cent) and one with that of hæmoglobin *G* (35 per cent). Hæmoglobin *G* moves under these conditions only slightly more slowly than hæmoglobin *Q*, and slightly faster than hæmoglobins *L*, *P* and *D*, but on chromatography at *p*H 6·0 using ion-exchange resin these hæmoglobins are easily distinguished[4].

There was a slight degree of anæmia (12 gm. hæmoglobin per 100 ml. blood), but this was attributed to pregnancy and iron deficiency. After delivery, and following treatment with iron, the anæmia was corrected and the hæmoglobin-level rose to 14 gm. per 100 ml. blood. There were no morphological abnormalities of the erythrocytes, and fœtal hæmoglobin was not found.

The woman became apprehensive when a special interest was shown in her blood. At first a family study was refused, and soon afterwards the whole family moved to an unknown address in Malaya.

Hæmoglobin *G* was first seen in a West African[6], and its genetic and electrophoretic characteristics have been described by Edington, Lehmann and Schneider[7]. Two further instances of hæmoglobin *G* have been seen in American Negro families by Schneider and Haggard[8], and one in a Nigerian family by N. A. Barnicot, E. M. Shooter and J. P. Garlick (personal communication). A hæmoglobin resembling *G* has been described by Schwartz *et al.*[9] in an Italian family. As this hæmoglobin migrated slightly faster than *G* on electrophoresis at alkaline *p*H, it is possible that this was *Q*. A re-examination by resin chromatography should decide this question.

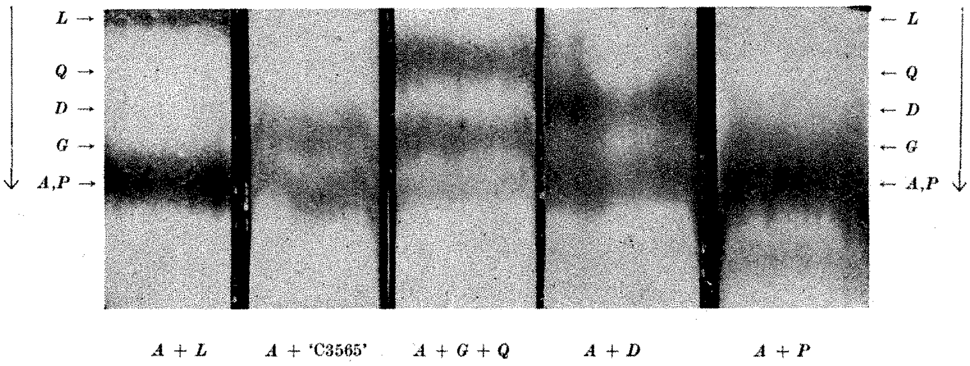

Fig. 1. Separation by resin chromatography on five 'Amberlite *IRC* 50' columns of hæmoglobin *G* from other hæmoglobins showing on paper electrophoresis at *p*H 8·6 only small differences in mobility. The small component in front of the *A* + *P* mixture is a 'pre-*A* band' sometimes seen in samples of hæmoglobin *A* by this technique. For details of technique, see ref. 11. Paper electrophoresis at *p*H 8·6 in order of mobility: *A*, *Q*, *G*, *L* ≡ *P*, *D*. Resin chromatography in order of mobility: *A*, *P* (*P* does not separate from *A*; the mixture forms a broad band), *G*, *D*, *Q*, *L*

Electrophoretic and chromatographic properties depend on the net charges of the globin molecule. Thus hæmoglobins *S* and *D* behave identically on open boundary and paper electrophoresis and in their chromatographic behaviour, but differ in the solubility of the ferrohæmoglobin, and on agar electrophoresis at *p*H 6·0. Hæmoglobins A_2 and *E* have been found to be identical by the current chemical and physical methods of analysis, yet preliminary investigations have demonstrated a difference in their amino-acid sequence (V. M. Ingram, personal communication). The finding of a hæmoglobin variant in this Chinese woman which has the electrophoretic and resin chromatographic properties of hæmoglobin *G* does not necessarily imply its complete identity with the variant seen in West Africans and American Negroes. However, this consideration applies to all identifications of hæmoglobin variants made on the basis of electrophoretic and chromatographic analysis[10].

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Comparative Kinetic Behaviour of Thrombin, Plasmin and Trypsin toward Synthetic Substrates

THROMBIN preparations catalyse the hydrolysis of synthetic arginyl[1] and lysyl[2] substrates. While plasmin and trypsin may appear as contaminants in thrombin preparations, we present here kinetic data for the action of these three enzymes toward *p*-toluenesulphonyl-L-arginine methyl ester (I) and the methyl and ethyl esters of lysine which rule out plasmin or trypsin impurities as the origin of the lysyl esterase activity of thrombin.

The kinetic studies were carried out with various thrombin preparations having the following activity towards (I), the substrate adopted for thrombin assays[3]: Seegers citrate-thrombin, 1,000 I units/mgm.; Seegers bio-thrombin, 100 I units/mgm.; Parke, Davis 'Bio-thrombin', 12 I units/mgm. None of these preparations is as pure as that which is attainable (at least 2,000 I units/mgm.) by the procedure of Rasmussen[4]. However, as will be shown, the state of purity does not affect the conclusions.

Experiments on the thrombin – lysine methyl ester reaction were carried out in 0·15 *M* potassium chloride at 25° using 100 I units of thrombin/ml. The hydrolytic reaction was followed by the *p*H-stat method[3] for 30 min. with appropriate corrections for non-enzymatic hydrolysis. The range of concentrations of the lysine methyl ester was limited to 0·001–0·01 *M* since, at higher concentrations, the ionic strength contributed by the dihydrochloride can reduce thrombin activity[3,5,6]. Nevertheless, a significant departure from first-order behaviour in substrate concentration was obtained, thereby permitting a Lineweaver–Burk analysis to be applied to the results.

Various aspects of the kinetic properties of the three enzymes under consideration appear in Table 1; a brief discussion follows.

(*a*) Whereas the plasmin – lysine ethyl ester and trypsin – lysine ethyl ester reactions attain the zero-order region at about 0·03 *M* and 0·02 *M* lysine ethyl ester, respectively, the zero-order region is not reached in the thrombin – lysine methyl ester reaction even at 0·1 *M* lysine methyl ester. Both plasmin and thrombin show zero-order behaviour towards (I) at concentrations of about 0·02 *M*, although the inhibition of plasmin at concentrations of (I) greater than 0·05 *M* (ref. 7) is not observed with thrombin[1,3].

(*b*) The maximum velocity V_m at *p*H 7·0 at 25°, obtained from the Lineweaver–Burk plot, is 0·0036 micromole lysine methyl ester/ml./min. per I unit of thrombin. This may be compared with the value[3] of 0·1 for the thrombin-induced hydrolysis of (I) at *p*H 8·0 at 25°. (By definition[3], 1 unit of thrombin hydrolyses 0·1 micromole of (I)/ml./min. at *p*H 8·0 at 25°.) Although k_3 cannot be computed on an absolute basis because the specific activity of thrombin is unknown, we can compute the ratio of k_3 for I and lysine methyl ester at the same enzyme concentration as the ratio of the values of V_m. This is 28 for thrombin, 1·4 for plasmin and 21 for trypsin.

(*c*) The Lineweaver–Burk plot gives a value of K_m = 0·070 *M* for thrombin on lysine methyl ester at 25°. This is significantly larger than 0·017 *M* for plasmin on lysine ethyl ester[7] at 37°, although a good comparison of K_m values cannot be made because of the difference in temperature. It is of interest to note that K_m for thrombin, plasmin and trypsin toward (I) seems to be identical.

(*d*) Because of differences in buffer ions, it is not possible to base any definite conclusions on differences in the *p*H optima.

Previous results[2] on the absence of STI inhibition of thrombin and the foregoing kinetic considerations indicate that the lysyl esterase activity in thrombin preparations does not arise from the presence of either plasmin or trypsin. Perhaps the strongest

Table 1. KINETIC DATA

Enzyme	Substrate concentration for zero order		Ratio of k_3 for (I) to k_3 for methyl or ethyl lysine ester	K_m		*p*H optimum	
	Lysyl ester	(I)		Lysyl ester	(I)	Lysyl ester	(I)
Thrombin	not reached (> 0·1 *M*)	0·01 *M* (ref. 3)	28	0·070 *M*	0·0043 *M* (ref. 1)	7	8 (ref. 3)
Plasmin	0·03 *M* (ref. 7)	0·015–0·05 *M**	1·4 (ref. 7)	0·017 *M* (ref. 7)	0·004 *M* (ref. 7)	6·5 (ref. 7)	9 (ref. 7)
Trypsin	0·017 *M* (ref. 8)	0·006 *M* (ref. 9)	21 (ref. 7)	—	0·004 *M* (ref. 10)	7·5 (ref. 7)	8 (ref. 9)

* Substrate inhibits at concentrations exceeding 0·05 *M* (ref. 7).

evidence that thrombin is itself a lysyl esterase is the finding that, regardless of the state of purification or type of preparation, the ratio of the activity of (I) to lysine methyl ester or ethyl ester remains constant. Thus, a 100-fold increase in purity resulted in only minor changes in the magnitude and shape of the *p*H – lysine methyl ester activity curve. The same holds true for the *p*H–(I) activity curves for these preparations[3].

In conclusion, thrombin has lysine esterase activity but, as discussed elsewhere[11], the lysine esterase site probably differs from the hydrolytic site for (I) and for fibrinogen. Further studies on thrombin are in progress.

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Vanadium Inhibition of Phospholipid Synthesis and Sulphydryl Activity in Rat Liver

THE effect of various transition elements on lipid and sterol metabolism has received attention in recent years[1]. For example, both vanadium and members of the rare-earth group are capable of producing a fatty infiltration of the liver. Furthermore, vanadium can cause a marked reduction in cholesterol and phospholipids[1,2]. In this connexion, work has been directed towards investigating a possible prophylactic action of vanadium against atherosclerosis[2]; it has been suggested that disruption of the endogenous balance of the transition elements in the liver could underlie the pathogenesis of this disease[1].

The increased *in vitro* oxidation of the fatty acid moiety of phospholipids occurring in the presence of vanadium[3] may account for the decreased phospholipid levels in animals fed vanadium, but it has not ruled out the possibility of an independent effect of vanadium in retarding liver phosphatide synthesis. This possibility was tested *in vivo* by measuring the incorporation of phosphorus-32 into liver phospholipids of rats shortly after injection of labelled phosphate.

Since Mountain *et al.*[4] have previously reported interference of sulphur amino-acid metabolism in vanadium toxicity, an additional group of animals was used to ascertain the effect of vanadium on the incorporation of L-methionine-^{35}S into liver protein, and on the amount of sulphydryl soluble in trichloracetic acids in the liver.

The Sprague–Dawley rats weighing approximately 170 gm. used in these studies were maintained on a 5 per cent casein diet[5] for 11 days. Animals were injected intraperitoneally with a vanadyl sulphate solution (0·75 mgm. vanadium in 0·5 ml. saline/100 gm. body-weight)[1] or saline (0·5 ml./100 gm. body-weight). The isotope (10 μc. of $NaH_2{}^{32}PO_4$ or 15 μc. of L-methionine-^{35}S) was administered by the same route immediately after the animals received the vanadium or saline. The rats were killed 3 hr. later. The livers, after being rapidly excised and weighed, were analysed in a manner similar to that described previously for phospholipid[5] and sulphur[6] turn-over. The relative specific activity of the phospholipids and the specific activity of total protein sulphur were calculated from the chemical and radioactive measurements.

Table 1. EFFECT OF VANADIUM ON PHOSPHOLIPID SYNTHESIS AND SULPHUR TURN-OVER IN LIVER OF RATS

	Saline controls	Treated with vanadium
No. of rats	6	6
Phospholipid relative specific activity*	0·101 ± 0·015	0·075 ± 0·018§
Protein sulphur specific activity†	12·8 ± 1·8	16·8 ± 1·0§
Sulphydryl compounds, mgm.‡ (TCA soluble)	0·37 ± 0·05	0·26 ± 0·03§

* Relative specific activity =

$$\frac{\text{specific activity of phospholipid-phosphorus}}{\text{specific activity of inorganic phosphorus}}$$

where the specific activity of phosphorus is defined as

$$\frac{\text{(counts/min. phosphorus-32)}}{\text{(mgm. phosphorus) (counts/min. of dose injected} \times 100)}$$

† Sulphur specific activity =

$$\frac{\text{(counts/min. sulphur-35) dekagm. of body-weight)}}{\text{(mgm. sulphur) (counts/min. of dose injected)}}$$

‡ Reported as mgm. of cystine per gm. of wet weight.

§ $P < 0·05$ calculated from the *t* test of significance. The figures preceded by the ± are the standard deviation.

The results are reported in Table 1. They suggest that the decreased phospholipid values observed in animals fed vanadium[2] result from inhibition of phospholipid synthesis and are probably augmented by oxidative degradation[3]. An alteration in sulphur metabolism is also apparent from the reduction of the sulphydryl content of the liver soluble in acid and from the increased turn over of protein sulphur in the animals which received the vanadium.

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Relative Stability of Adrenaline, Noradrenaline and 5-Hydroxytryptamine subjected to Various Simple Treatments

WHEN the distribution of active materials in vertebrate tissue is being studied, it is necessary to free tissue extracts from substances which interfere with the bioassay of 5-hydroxytryptamine. Garven[1] has described a method for the destruction of polyphenols by the polyphenol oxidase present in mushroom juice. The juice contains both polyphenol and monophenol oxidase, and her method therefore makes use of the faster inactivation of adrenaline and noradrenaline by polyphenol oxidase than of 5-hydroxytryptamine by monophenol oxidase. The present method depends on the differential stability of 5-hydroxytryptamine, adrenaline and noradrenaline in alkaline solution.

Table 1. EFFECT OF TEMPERATURE AND *p*H UPON RESPONSE OF RAT STOMACH TO SOLUTIONS CONTAINING 5-HYDROXYTRYPTAMINE (5-HT), ADRENALINE (Ad) AND NORADRENALINE (nor-Ad)

All recoveries as percentage (mean ± standard error) of response to untreated solutions containing 10 or 20 mμgm./ml. 5-hydroxytryptamine base (5-hydroxytryptamine creatinine sulphate, May and Baker)

Figures in brackets show number of separate experiments performed

*p*H	Duration of treatment (min.)		Percentage of response to control sol. (5-HT only, *p*H 6·8–7·8, untreated)			
	Room temp.	98° C.	5-HT	5-HT + Ad 1 μgm./ml.	5-HT + nor-Ad 1 μgm./ml.	5-HT + Ad 1 μgm./ml. + nor-Ad 1 μgm./ml.
6·8–7·8		1	99·3 ± 0·75 (4)	0 (2)	60·5 ± 10·5 (2)	—
		5	97·0 ± 6·00 (2)	—	—	97·0 ± 8·00 (2)
	120–240		100·0 ± 3·30 (15)	Relaxation (6)	Relaxation (6)	Relaxation (2)
9·6		1	97·3 ± 1·50 (4)	93·0 ± 1·00 (2)	91·0 ± 3·00 (2)	—
		2	86·0 (1)	—	—	78·0 (1)
	120		—	—	0 (1)	—
10·8–11·2		1	67·8 ± 2·92 (4)	55·0 ± 5·00 (2)	76·5 ± 7·50 (2)	—
	5		96·5 ± 4·50 (4)	0 (5)	—	—
	30		98·0 ± 2·00 (2)	114·0 ± 2·00 (2)	—	—
	60		96·9 ± 3·78 (7)	101·8 ± 3·11 (6)	—	103·0 (1)
	120		88·2 ± 2·97 (5)	92·5 ± 12·50 (2)	92·3 ± 3·80 (4)	80·0 (1)

Solutions containing 10 or 20 mμgm./ml. 5-hydroxytryptamine were prepared, ± 1 μgm./ml. adrenaline and ± 1 μgm./ml. noradrenaline, in Tyrode's solution bubbled for 30 min. previously with a gas mixture of 5 per cent carbon dioxide, 95 per cent oxygen. The volume (0·2–0·4 ml.) of analytical grade sodium hydroxide to give the required *p*H was added to 25-ml. aliquots of solutions in 50-ml. stoppered flasks or test-tubes. The solutions were well mixed by shaking and either left to stand on the bench at room temperature or heated in a water-bath at 98° C. and then cooled in iced water. Analytical grade hydrochloric acid was added to restore the *p*H to neutral, the solutions were well shaken and remained on the bench at room temperature until they were assayed (about 2 hr. later). There is no significant loss of activity during this time (*P* > 0·2). The *p*H of the solutions was checked initially with Johnsons's narrow range indicator papers and in critical experiments by an E.M.I. direct-reading *p*H meter.

5-Hydroxytryptamine was assayed upon the rat stomach preparation[2] in Tyrode's solution at 38° C. Doses were given according to a 'Latin square' design. In all experiments the test solutions were compared with untreated solutions of 5-hydroxytryptamine to which Tyrode's saline had been added in volumes equal to those of sodium hydroxide and hydrochloric acid. All recoveries are expressed as percentage of response to untreated solutions containing 5-hydroxytryptamine only.

Table 1 summarizes the results of fifteen experiments. Adrenaline and noradrenaline in concentrations 50–200 times those which were found to abolish the response of the tissue to the stated amounts of 5-hydroxytryptamine are completely inactivated by standing for 30–60 min. at *p*H 11 without loss of 5-hydroxytryptamine itself. Heating to 98° C. for 5 min. at *p*H 7·8 is equally effective. Heating for 1 min. at 98° C. and *p*H 9·6 leads to a small loss, and at *p*H 11 to a considerable loss of 5-hydroxytryptamine activity. This last result differs from that reported by Pernow[3].

Human serum to which adrenaline, noradrenaline and 5-hydroxytryptamine had been added was extracted by addition of four volumes of acetone[4]. When sodium hydroxide was added to the extracts to give a *p*H of 10·5–11·0 for 30–60 min., adrenaline and noradrenaline were destroyed whereas 5-hydroxytryptamine was unaffected. Three such experiments gave recoveries of 5-hydroxytryptamine between 92 and 100 per cent of the control value (96·2 ± 1·7).

Thus both adrenaline and noradrenaline in a concentration of 50–200 times that of 5-hydroxytryptamine—a ratio which occurs in certain parts of the brain of vertebrates[5,6]—are selectively destroyed by treatments which have little or no effect on the concentration of 5-hydroxytryptamine.

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Application of Direct Photographic Photometry to Preparative Electrophoresis

THE supporting medium of most preparative methods of electrophoresis includes a solidified gel or porous solid in order to reduce thermal convection[1]. A buffer stabilized in the form of a clear solution, without a solid support, would have the advantages of avoiding adsorption effects between the migrating molecule and the solid, and would make it possible to follow the migrating substances by direct photometric procedures[2]. A method of electrophoresis has been described which uses, as a medium, a thin film of buffer solution[3]. Thermal convection can be effectively controlled by dissolving in the buffer a sufficient quantity of gelling agent to impart a trace of rigidity or thixotropy. Not enough is added to cause a loss of fluid characteristics (that is, to run freely when tilted) or a loss of transparency. The amount of protein that can be separated can be increased for preparative purposes by increasing the thickness of the buffer from that of a thin film to a solution 1 cm. or more. Direct photographic photometry applied to the separation and isolation of serum proteins by this method was accomplished by the following procedure.

A cell bottom 6·5 in. × 13 in. was constructed of two 6·5 in. squares of Corning No. 7910 glass. These were glued together with glass strips to form a rectangular container. 'Difco' agar, one of various gelling agents which can stabilize in trace amounts, was added to a 0·02 *M* veronal buffer, *p*H 8·6, to a concentration of 0·16 gm. per cent. It was dissolved by boiling, and 500 ml. of the solution was poured into the cell while still warm. Cellulose sponges were used for electrical contact with electrode vessels, each filled with the same solution up to the same level as in the cell. The solution was permitted to stand for a half-hour, and a potential gradient of 6·1 V./cm. was then applied. 1 hr. later the serum was introduced by attaching a 14 cm. × 0·6 cm. piece of Whatman No. 17 paper with thread to a plastic frame, wetting the paper with serum, and then inserting the frame down into the buffer solution along vertical grooves which had been prepared inside the glass sides. Serum can also be applied by solidifying a block with agar.

The proteins were followed at various times during the course of their migration by inserting photographic plates into a space left vacant under the cell. These were exposed to light of 283 mμ wave-length for 11 min. A Beckman *D.U.* monochromator with a hydrogen lamp was used as light source. The monochromatic light beam was extended horizontally for 18 ft., then deflected by means of an aluminium mirror down through the electrophoretic cell. The photographic plates were developed, and the positions of the protein components were determined by means of a centimetre scale drawn on the bottom of the cell (Fig. 1). The current was then disconnected, and the protein fractions were separated by inserting aluminium sheet dividers down into the solution at appropriate positions along the centimetre scale. The dividers were connected by tape along the outside of the cell, which was placed in a freezer. The frozen sections were removed individually, thawed, and the agar removed by centrifugation. After concentration to approximately the original volume, each fraction was subjected to electrophoresis, along with the original serum, by the fluid film technique. The results, after staining with amido black, are presented in Fig. 2. Densitometer curves were obtained from the stained electropherogram and from the third photographic plate of Fig. 1.

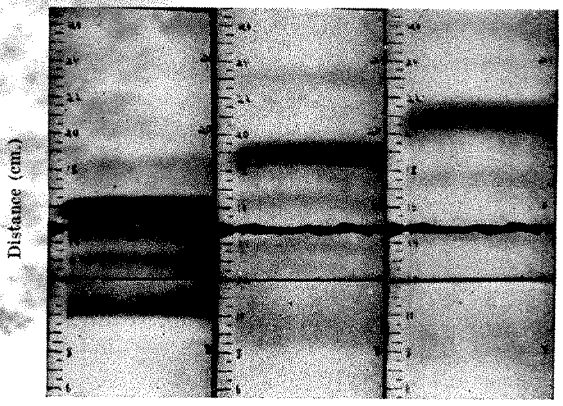

Fig. 1. Printed photographic plates obtained at 2·5, 4·5 and 5·5 hr. of migration. The line at 12 cm. was due to the frame used to apply serum, and the irregular line at 14·7 cm. was caused by the glue connecting the two silica plates of the cell bottom

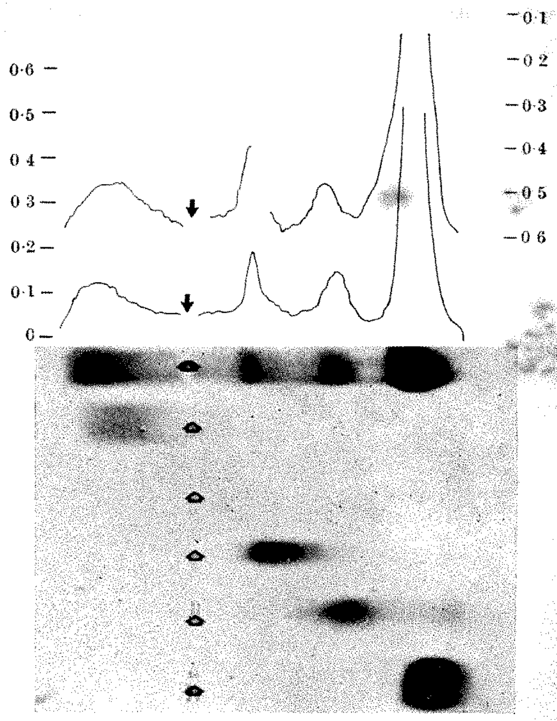

Fig. 2. Film electrophoresis of the original serum and components included in the following sections of the preparative cell: 6–10, 10–13, 13–16, 16–19 and 19–22 cm. The top curve gives the absorbancy along the last photographic plate of Fig. 1, right-hand scale, while the lower curve represents the stained pattern below it, left-hand scale. Arrows indicate position of application

Although the volume of serum applied above was only slightly more than 1 ml., considerably larger amounts can be used. The ability to follow the course of the proteins during electrophoresis and to isolate the individual components by the simple method described, without continuous sectioning or analysis along the migration path, may prove of value for various purposes. The use of ultra-violet photographic photometry for quantitative measurements is being investigated.

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Co-ordination in Thorium-IV Acetylacetonate

Although the number of atomic species with co-ordination number eight is not large, little is known about the structure of eight-co-ordinated complexes. Up to now only two of five possible polyhedra have been established for this co-ordination, namely, a trigonal dodecahedron and an Archimedean square antiprism[1], while cube, triangular face-centred and rectangular face-centred trigonal prisms have not yet been observed. These polyhedra were proposed on the basis of quantum-mechanical calculations on the form of hybrid bond orbitals.

In general, it is possible to predict the co-ordination polyhedron for a given complex if the valency electron orbitals are known and if the co-ordination is not high. This is not the case with heavy atoms, particularly with actinides, where there are many electrons distributed over *s*, *p*, *d* or *f* orbitals, so that we cannot recognize which is the most favourable configuration for covalent bonding[2]. The direct experimental verification, for example, the X-ray analysis of the crystal structure of heavy metal complexes, is therefore of considerable interest in inorganic stereochemistry.

Metal acetylacetonates of formula $M^{IV}(C_5H_7O_2)_4$, where M^{IV} is zirconium, hafnium, thorium, uranium, polonium or cerium with the co-ordination number eight, are a very promising subject for such analysis. We started our work with the thorium compound[3].

The crystals of thorium acetylacetonate are monoclinic holohedral, the space group being $C_{2h}^5 - P2_1/c$ with four molecules in the unit cell which has the dimensions: $a = 11 \cdot 67$ A.; $b = 12 \cdot 69$ A.; $c = 16 \cdot 95$ A.; $\beta = 112° \, 15'$.

Multiple-film Weissenberg photographs, taken with copper $K\alpha$ radiation, were used to obtain intensity data for $h0l$ and $0kl$ reflexions. The relative intensities were determined from the optical densities measured at the centre of each spot by means of a microdensitometer. In order to facilitate the absorption correction the specimen was made cylindrical by grinding. The thorium atom parameters were obtained from [010] and [100] Patterson projections. The signs of the structure factors $F(h0l)$ and $F(0kl)$ were determined using only thorium atom contributions and then the corresponding projections of electron density distribution were computed by the Fourier synthesis. Besides thorium atom maxima at $x = 0 \cdot 191$; $y = 0 \cdot 146$; $z = 0 \cdot 200$, a large number of peaks appeared in both projections. A careful examination of the [010] projection revealed a six-membered ring containing the thorium atom peak as well as both methyl-group peaks. It belonged to the acetylacetonate ring which was nearly parallel to the plane of projection. Next, a trial procedure was undertaken which consisted mainly of casting the shadow of wire and sphere models on both electron density maps by means of a distant source of parallel light. At first the square antiprism as a co-ordination polyhedron was assumed, since it involved only three considerably different geometrical isomers (Fig. 1) with the symmetry D_4, D_2 and C_2, respectively. This first step was fruitful and all peaks on both projections were explained by the structure based on the configuration (*b*) in Fig. 1.

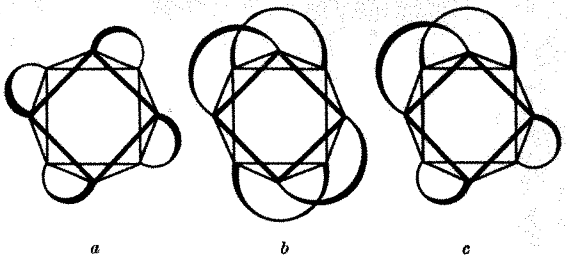

Fig. 1. Geometrical isomers of an eight co-ordinated acetylacetone complex in the Archimedean square antiprism form

The model of the thorium acetylacetonate molecule related to both projections is shown in Fig. 2. Besides the diffraction effect caused by the heavy thorium atom, the maxima in the projections overlapped in many places, which interfered with an exact evaluation of atomic positions. The structure is now being refined so that the present results are only preliminary.

The bond-length Th—O is $2 \cdot 41$ A., and the OThO bond angle is 70°. The O . . . O distance within an acetylacetonate ring amounts to $2 \cdot 74$ A. and the distances between two adjacent rings are $3 \cdot 05$ A. and $3 \cdot 10$ A., along the edge of square and triangular faces, respectively. It follows, therefore, that the actual co-ordination polyhedron is a square antiprism with a slight characteristic distortion. An idea of the amount of distortion can be obtained if we take the Th—O bond length for granted, when the ideal square antiprism requires an edge of $2 \cdot 93$ A., a distance of

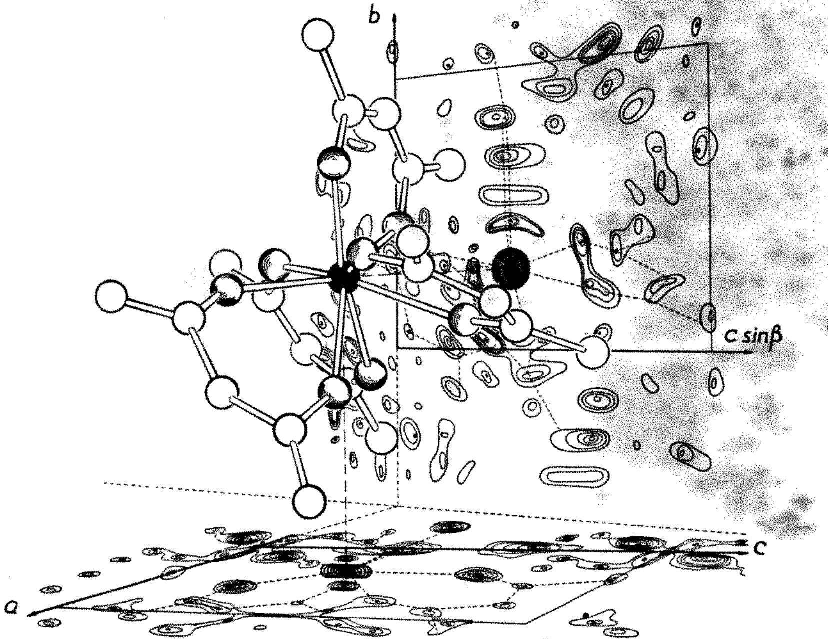

Fig. 2. Perspective view of the model of thorium-IV acetylacetonate molecule as obtained from ($h0l$) and ($0kl$) electron-density maps

2·47 A. between square faces (observed value 2·53 A.) and a bond angle of 75°.

Further analysis of the structure is now in progress and the results will be published in detail elsewhere.

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Absorbents for Aldehydes and Olefins

The usual forms of absorbents for aldehydes, such as ammonia and bisulphite solutions, cannot readily be used in vacuum systems because they are liquid and volatile. A very convenient absorbent may be made by suspending on 25–52 mesh powdered firebrick ('Fossalsil') 25 per cent by weight of a mull of sodium bisulphite in ethylene glycol. We have repeatedly used this powder packed in 10 cm. of a 15 mm. internal diameter tube to absorb the butyraldehyde remaining in a mixture after a photolysis. Subsequent analysis of the reaction products indicates that less than 0·3 μmole out of the initial 500 μmoles remains unabsorbed after the vapour has been passed three times through the packed tube. Acetone is not similarly absorbed.

An excellent absorbent for olefins may similarly be made from a mixture of 9 gm. mercuric acetate, 3 gm. mercuric nitrate and 20 gm. ethylene glycol on 100 gm. of firebrick.

This research was supported by a grant from the Petroleum Research Fund administered by the American Chemical Society. Grateful acknowledgment is made to the donors.

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Formation of a Transition Metal–Hydrogen Bond in Aqueous Solution

There are several known transitional metal complex systems which are concerned with either the absorption or evolution of molecular hydrogen, and some of them, for example the copper acetate in quinoline system, can function as hydrogen-transfer systems[1–3]. It has been suggested by many workers in the past that complexes containing hydrogen bonded to a transitional metal are involved in these systems, but direct proof for the existence of such bonds has been lacking.

A sufficient number of complex compounds containing metal-hydrogen bonds has now been studied by high-resolution nuclear magnetic resonance methods to permit the specific characterization by this technique of a proton bound to a transitional metal. Thus the compounds $(C_5H_5)_2ReH$, $(C_5H_5)_2ReH_2^+$ (ref. 4), $HCo(CO)_4$ (ref. 5), $H_2Fe(CO)_4$ (ref. 6), $HMn(CO)_4$ (ref. 7), $H\mathit{M}(CO)_3(C_5H_5)$ [M = Cr, Mo, W] (ref. 8), $HPtCl(PR_3)_2$ (ref. 9), and $(C_5H_5)_2\mathit{M}H_2$ [M = Mo, W] (ref. 7) have all been shown to have proton resonances shifted to 450–800 cycles/sec. (at 40 Mc./s.) relative to water, on the high field side.

During the course of studies of such compounds and related systems we have examined the cobaltous cyanide–potassium cyanide system, which has been rather carefully studied by Winfield and others[1 2 10]. In aqueous solutions a proton resonance at a position characteristic for a proton bound to the metal atom has been detected, at 698 ± 2 cycles/sec. (at 40 Mc./s.) relative to water. The resonance is not observed at cyanide/cobalt ratios less than 3·5, and it is not affected by excess cyanide up to a cyanide/cobalt ratio of 8·0. The presence of an atmosphere of hydrogen above the solution is not necessary for the appearance of this resonance line, so that the proton bound to the metal is clearly derived from water. The rest of the water molecule, either as free OH radicals or as oxygen, presumably oxidizes the aquo cobaltous cyanide complex. The proton resonance disappears on admission of oxygen and other oxidizing agents to the solution. While there is, as yet, no specific information concerning the nature of the hydrogenated species, it seems reasonable to postulate that it is the $[HCo(CN)_4]^=$ ion. The large chemical shift of the proton resonance shows that the proton in such a species is exchanging with water in the aqueous alkaline solution only very slowly, and the average chemical life-time of the proton on the metal atom must be greater than about 10^{-4} sec.

These studies will be more fully described elsewhere.

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A Radiocarbon Profile in the Tasman Sea

During recent hydrological investigations in the eastern Tasman Sea by the New Zealand Oceanographic Institute a series of sea-water samples was collected for carbon-14 analysis as mentioned recently by Rafter and Fergusson[1].

The sampling position (New Zealand Oceanographic Institute Station *A*344) was in approximately latitude 37° 25′ S.; longitude 170° 35′ E. over

Table 1

Depth (metres)	Volume carbon dioxide (litres)	^{14}C activity w.r.t. *Pinus* (per cent)	'Age' (before present) (years)
0	12·4	+1·01 ± 0·50	0
100	15·0	−0·2 ± 0·45	100 ± 50
280	18·0	−6·4 ± 0·35	590 ± 50
830	17·4	−8·0 ± 0·38	720 ± 50
1,400	21·0	−16·1 ± 0·40	1,480 ± 60

the head of the New Caledonia Trough in a depth of some 1,900 m. The station was worked on February 14, 1957, under the direction of Dr. R. W. Burling from R.N.Z.F.A. *Tui*. 40 gallon samples were obtained, using an open-ended sampler with a capacity of 20 gallons. Sample depths, the carbon-14 activity of samples with respect to that of the softwood *Pinus radiata*, the New Zealand contemporary standard, together with the derived apparent ages (namely, the time elapsed since air-sea equilibrium obtained), are given in Table 1. These analyses were made in the Nuclear Sciences Division of the Department of Scientific and Industrial Research, Lower Hutt, under the direction of Mr. T. A. Rafter.

The hydrological situation is described in terms of the results of a standard reversing bottle cast made at this station (Table 2). Water analyses and reduction of the results were by me.

Table 2

Depth (metres)	Temperature (°C.)	Salinity (‰)	Dissolved oxygen (ml./l.)
0	21·15	35·45	4·82
10	21·14	35·46	5·10
20	21·11	35·46	5·54
30	21·00	35·45	6·45
50	19·86	35·44	7·18
75	16·94	35·45	5·77
100	16·10	35·46	5·08
150	14·90	35·46	3·82
200	14·09	35·43	2·50
300	12·61	35·26	1·00
400	11·10	35·11	0·87
500	9·76	34·99	1·01
600	8·70	34·90	1·29
800	6·88	34·76	1·88
1,000	5·47	34·66	2·51
1,200	4·39	34·64	3·18
1,500	3·36	34·71	3·80
1,800	2·71	34·79	4·29

The observations have been plotted in the form of temperature, dissolved oxygen and 'age' as functions of salinity (Fig. 1). By projecting the tangents on the temperature–salinity curve, the three primary water types giving rise to the observed characteristics (assuming predominant vertical mixing) have been derived. *A* is the upper subtropical water at a depth of about 160 m., water above this depth being subject in large measure to external (climatic) influence. *B* is the core of the Antarctic intermediate water at about 1,100 m. (originating in surface layers near the Antarctic Convergence) and *C* the deep water (probably entering the Pacific from the Atlantic via the India Ocean) which here extends to the bottom. A discussion of the history of these water masses forms the basis of a consideration (in preparation) of the full hydrological results of the cruise from which the results given here were derived. Particularly noteworthy are the absence of circumpolar bottom water (probably due to isolation by bottom topography) and the significant increase in salinity of the deep water over that found by earlier investigations (for example, *Dana* station 3650 (1920)) in this area. This increase has been traced over a large area of the south-west Pacific.

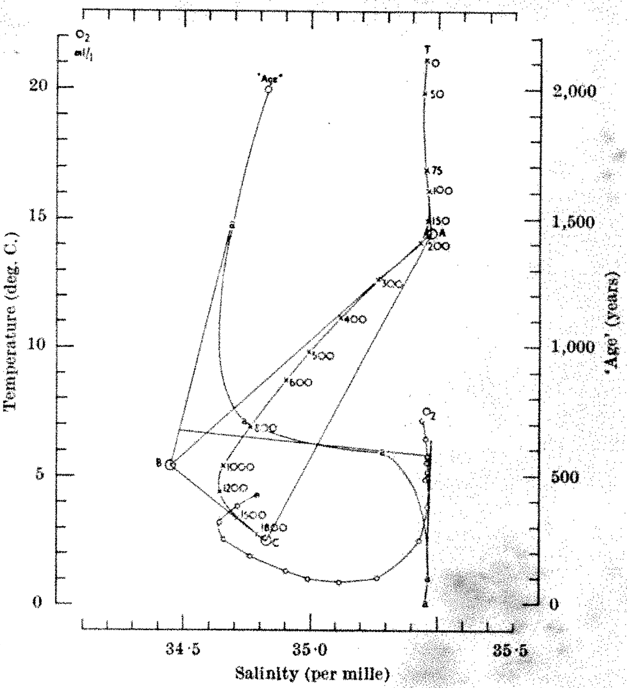

Fig. 1. For station *A*344 the temperature (*T*, ×———×), dissolved oxygen content (O_2, ○———○) and carbon-14 'age' (*a*———*a*) are plotted as functions of salinity in the water column over the New Caledonia Trough in the eastern Tasman Sea on February 14, 1957. *ABC* is the triangle of mixing derived from the temperature–salinity correlation, beside which is entered a depth scale (small figures) in metres

If the carbon-14 activity can be regarded as a conservative water property, the mixing diagram constructed from the 'age'-salinity correlation should indicate a similar water-mass structure to that implied by the temperature–salinity curve. From a graphical construction based on the observations in Fig. 1 it is found that the measured 'ages' are consistent with the temperature–salinity diagram if 'age' values for the primary masses are as follows: *A*, 600 years, *B*, 600 years and *C*, 2,000 years. The prolonged isolation of the deep water (*C*) is notable and may be compared with the value of 2,540 ± 100 years reported by Brodie and Burling[2] from a depth of 2,643 m. in the Southern Ocean south of New Zealand in December 1956. It is likely that the point *C* in Fig. 1 lies above the core properties of deep water because of the relatively shallow depth.

This elementary approach towards accounting for the variation in the carbon-14 activity of the water column in terms of vertical mixing between the main oceanic water masses will need closer examination. Also, because of the time taken to obtain a sufficient volume of water for each determination, only a few points in the vertical profile are sampled. It will be important to see that future samples are adequately located with respect to the turning points in the salinity–depth relationship.

It will be interesting to follow the variation of the 'primary' values derived in the above manner at various points along the cores of the principal water masses, particularly the Antarctic intermediate layer. With the magnitude of lateral mixing defined from temperature–salinity data, it should be possible to make a direct estimate of the velocities involved.

It is noted that the 'age' and distribution of dissolved oxygen in Fig. 1 are of different character, indicating that the concentration of oxygen at depth is here a function of (presumably) biological activity rather than an index of the time since free exchange between air and sea was possible.

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Vaporization of Projectiles on Impact

DR. K. H. LIH, director of this Institute, has directed my attention to the article of Dr. F. P. Bowden and Mr. J. H. Brunton about the damage to solids by liquid impact[1]. It would be interesting to know if these authors have noticed the effect of 'explosion' of the water particles when they hit a hard surface at high speeds, similar to that which we observed when making experiments with different metal liners used in so-called 'hollow' or 'shaped' explosive charges; although, of course, the velocities of the liner particles far exceed those which Bowden and Brunton used for propelling their water drops. In the *Scientific Monthly* of February 1951, p. 79, it was remarked that: "Ballistic experiments have shown that particles, travelling at velocities about 4,250 ft./sec., *explode into vapour* on striking the target".

That this is actually so is proved by Fig. 1, which shows the surface of the second steel block (diameter 4 in., height 4 in.) hit by the jet particles which had already passed through the first block of the same dimensions; the vapour of the exploding metal particles condensed on the cold surface and left a white spot around the point of impact. That such spots are not produced by droplets of molten metal forced between the two blocks, but by the condensed vapour, was proved by the following experiment: a brass liner was fired into a steel block provided with several apertures running perpendicular to the jet passage; when the block was cut lengthwise it was discovered that at some places in these holes zinc vapour had condensed, which could only happen if at least part of the metal was in gaseous state.

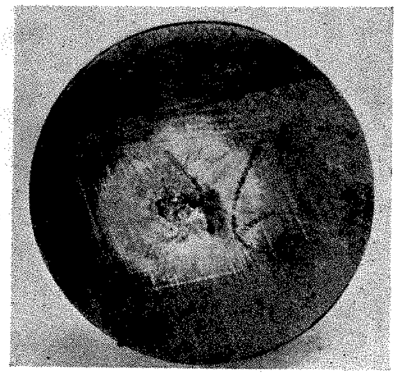

Fig. 1. Condensed metal vapours of exploding jet particles imprinted on the surface of the second steel block

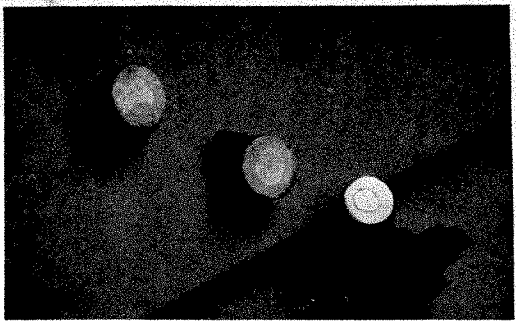

Fig. 2. Cross-sections of 'slugs' showing the copper cores

Fig. 2 explains the formation of the 'slug': small additional copper cones were fixed into the steel liners; the charges were fired horizontally into a sand box, and the metal fragments recovered. The 'slugs' were found to be solid steel bodies with a copper core, which proves that, contrary to some theories, the liners are not turned 'inside out'—at any event at the top—but simply compressed by the force of detonation and torn from the rest of the liners, the lower parts giving most of the high-velocity fragments which penetrate deeply.

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Effect of Solar Flares on Earth Satellite 1957β

FIG. 1 appears to demonstrate a correlation between the fluctuations in the rate of decrease of the period of satellite 1957β and contemporaneous variations in total intensity of solar flares.

The upper part of Fig. 1 is a block diagram with ordinates computed from the daily sum, over all observed flares, of their (area × duration). To aid comparison, I have plotted only the arithmetic mean of this sum over periods between successive satellite observations. The scale is shown by the arrow, which denotes the ordinate equivalent to 1,000 sq. deg. min./day (for example, 1 hr.-long class 3 flare per day). The data have been compiled from the Fraunhofer and Meudon daily Sun disks, and I am indebted to Mr. J. H. Reid, of the Royal Observatory, Edinburgh, for this information. For simplicity only flares of class 2 and above were included in the calculations.

The orbital data of the lower part of the figure were prepared from a graph of various observations published by the Royal Aircraft Establishment, Farnborough, for which I am indebted to Mr. D. G. King-Hele. The ordinates denote the difference between the observed rate of decrease of period and a theoretical figure for this quantity (relating to the same stage of the life-time). Because the theoretical rate varies monotonically with time, its introduction in no way obscures the fluctuations of the observed rate, but rather serves to facilitate their presentation. Similarly, the derivation of the theoretical figures used is immaterial in the context.

The similarity of the two sets of fluctuations, even in some small details, is suggestive. If it is conceded that it may not be purely coincidental, it would be

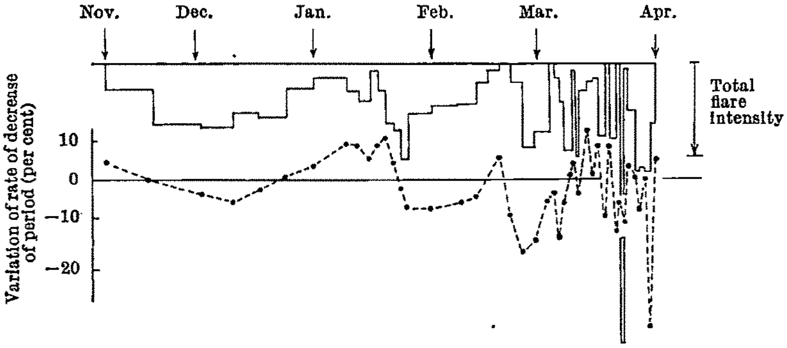

Fig. 1

valuable to establish a possible mechanism for the dependence.

However, it is to be noted that the sense of the relation is such that flares would have to be associated with a temporary decrease in air density, and/or temperature, within the lower ionosphere. (The satellite perigee fell from 140 to 100 miles height during the time shown.) To account for the diagram, this reduction would seemingly have to happen on a world-wide scale, as the perigee ranged during the life-time from middle to equatorial latitudes, and through daylight and night zones.

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Reversals of the Earth's Magnetic Field

Among the many surprising results of studies of the natural remanent magnetization of rocks[1], one of the most curious has been the conclusion that the Earth's magnetic field has undergone changes of polarity; that, in fact, reversals of the main field have been a persistent feature of its behaviour. Normal and reversed fields could equally well exist, according to the dynamo theory of the Earth's magnetism[2], but it is not known whether a means of transfer from one field to the other exists.

Several years ago, E. C. Bullard[3] examined the behaviour of a simple homopolar disk dynamo in some detail, and suggested that systems of such dynamos, together with electrical loads, might provide useful analogies to homogeneous fluid dynamos. He found an interesting oscillatory behaviour of the current and angular velocity for a single dynamo, but there was no phenomenon of reversal. Recently, T. Rikitake[4] set out the equations for two disk dynamos coupled to one another, and from a numerical integration concluded that it was possible for the currents in their coils to change sign; in other words, the fields produced could show reversals, at least initially.

Using the digital computer EDSAC II at the University of Cambridge Mathematical Laboratory, I have been able to carry out much more extended numerical integrations of these equations for a range of parameters and initial conditions. These have exhibited some very subtle types of behaviour, and show that reversals can occur under a wide range of conditions. The system has two states of equilibrium, with the currents for one the reverse of the currents for the other. The equilibrium is stable for small oscillations, but for larger departures from the steady-state values many of the solutions oscillate first about one point of equilibrium and then about the other. Fig. 1 shows a striking example of this behaviour; the current in the coil of one dynamo only is given. It oscillates in one manner for some time, reverses for a single oscillation, and reverts to the original manner; then later a whole series of the reverse oscillations takes place. The current in the other coil behaves very similarly in this case, but I have found cases in which one current oscillates, changing sign, whereas the other never changes sign.

The significance of these results lies largely in the fact that the phenomenon of reversal can occur, both in the sense of a change of polarity and in the sense of a true reversal of behaviour corresponding to a change from oscillations about one state of equilibrium to those about another. In a similar way, reversals of the terrestrial field may be occasional phenomena in the course of continual oscillations of considerable amplitude. There is some evidence that the field intensity has decreased in the past 2,000 years[5]. Such changes would affect radiocarbon dating[6], and C. Crowe (see following communication) has found that errors in such dates over the past 3,000 years might well be consistent with an increase and then a decrease of the Earth's field. Thus, oscillations of the main field with a period of some thousands of years, with reversals at intervals of hundreds of thousands of years, would be quite conceivable.

There is no guarantee that the homogeneous dynamo believed to exist in the Earth's core will behave similarly to two coupled dynamos. I hope to examine some more elaborate models which may be more closely analogous to the former, but it would be unwise to press the analogy too far. For example, two dynamos of a scale appropriate to the core would have periods measured in years rather than thousands of years; Bullard[3] has suggested that this is because the system includes nothing equivalent

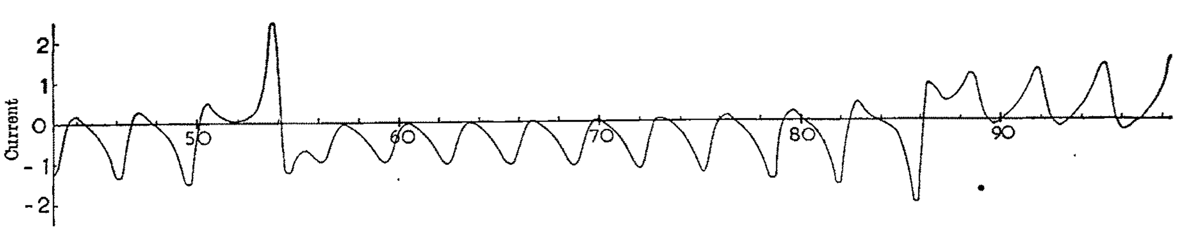

Fig. 1. Current in one dynamo vs. time (in units scaled to become dimensionless). The equilibrium values of the current are ±0·5

to a Coriolis force. (The periods of days observed in some magnetic stars[7] might, however, be reproduced by this model.) Nevertheless, the fact that large-scale oscillations in this simple system can lead to reversals is surely an indication that the origin of reversals of the Earth's main field, and the nature of its variation with time, "though puzzling questions, are not beyond all conjecture".

I wish to thank the National Research Council of Canada for a fellowship supporting this research, and the University of Cambridge Mathematical Laboratory for use of EDSAC II.

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July 10.

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Carbon-14 Activity during the past 5,000 Years

VARIATIONS during the past 5,000 years of the concentration of carbon-14 in living material have been investigated with the aid of available radiocarbon dating measurements made with samples which have died at known times.

If the difference, Δt, between the actual age t and the radiocarbon age t' of a specimen is attributed to an initial activity not the same as that of present living material, the change in activity relative to that of the present is given by:

$$R \doteqdot \lambda \Delta t \quad (\lambda \Delta t \ll 1)$$

where $\Delta t = t - t'$ and $\lambda = 1 \cdot 24 \times 10^{-4}$ year^{-1}.

This ratio has been calculated in cases where both a radiocarbon and a reasonably accurate historical or archæological date are available[1]. First, account must be taken of systematic errors in t', chiefly of the use by most radiocarbon dating laboratories of different standards of present activity. This has been attempted by comparing the ages obtained in cases where laboratories have dated the same sample or different portions of a specimen. The scheme adopted, which correlates the results from the various laboratories with those obtained at Groningen, is shown in Table 1. Change in activity (R) *versus* time is shown in Fig. 1.

The activity appears to have followed a cycle with a maximum change of about 10 per cent in the past 5,000 years, taking into account some recent results[2,3]. There is evidence of a sharp peak of about 10 per cent approximately 2,000 years ago. The rapid decrease in the past 100 years or so has been attributed to the 'Suess' effect of dilution of the atmospheric reservoir of carbon-14 due to combustion of fossil fuel[4].

Table 1. SCHEME CORRELATING RESULTS FROM OTHER LABORATORIES WITH THOSE FROM THE UNIVERSITY OF GRONINGEN

	Years to be added to or subtracted from all dates
University of Heidelberg	−375
University of Chicago	0
Institute of Archæology	0
Lamont Geological Observatory	+400
University of Michigan	+400
Swedish Geological Survey	+525

The estimated error of ±100 years in these corrections is not included in the activity error.

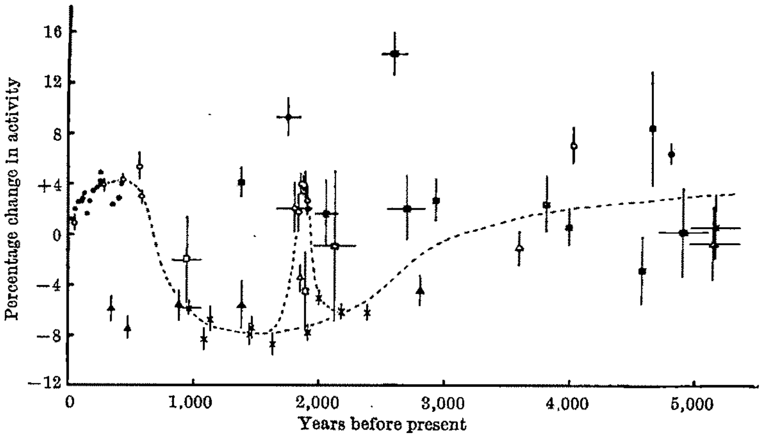

Fig. 1. Change in activity relative to that of the present *versus* time. ■, Chicago; ●, Groningen; ○, Heidelberg; △, Inst. of Arch.; ▲, Lamont; □, Michigan; ×, Stockholm; --- proposed trend. Error in time is ±100 years or less where not shown. The Groningen and Heidelberg results in the past 500 years are obtained from refs. 2 and 3

Regional differences in activity greater than 1 per cent are precluded by the treatment of data in this paper. Evidence for differences of less than about 1 per cent during the past few centuries has been given[2].

Errors in radiocarbon dates of the magnitudes found may be produced by the variations in the intensity of the Earth's magnetic field which have been indicated by measurements of the remanent magnetism of Roman bricks[5]. A cyclical variation in intensity corresponding to that of the activity would not conflict with a dynamo theory of the origin of the Earth's field (Allan, D. W., preceding communication), or with previous work on variations over a long period of the Earth's magnetic dipole[6]. It has been suggested that some activity changes may be due to variations in vertical mixing in the oceans[2]. A recent analysis of the 'Craig' carbon-14 reservoir model[3] indicates that a change of about 10 per cent in the activity would be caused by a change of approximately 100 per cent in the rate of production of carbon-14. Changes of several hundred per cent have been observed in the intensities of the secondary cosmic-ray neutrons[7] and other components[8] following large solar flares, and the effect of such events, though years apart, may be significant.

Changes in activity may be due to combinations of these effects. A recent communication[9] suggests a method of separating the effect of variation in the intensity of the magnetic field from the others. It is hoped that the above results will provide some information for further work.

Thanks for their advice are due to Mr. R. M. Cook, reader in classical archæology, and members of the Department of Archæology and Anthropology, the Sub-Department of Quaternary Research, and this

Department. Assistance in the form of a scholarship from the Royal Commission for the Exhibition of 1851 is gratefully acknowledged.

C. Crowe

Department of Geodesy and Geophysics,
Cambridge. July 12.

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Infra-Red Transmission Limits and Reflectivity of Lithium-6 Fluoride and Lithium-7 Fluoride

The Industrial Group of the United Kingdom Atomic Energy Authority has made small quantities of lithium compounds, containing different proportions of the isotopes ^{6}Li and ^{7}Li, available to its Research and Development Laboratories at Capenhurst. The material is being used to determine how altering the isotopic ratio ^{6}Li/^{7}Li in lithium compounds affects certain physical properties of these compounds.

Some of the material has been converted to lithium fluoride from which single crystals have been grown in the Natural Philosophy Department, Aberdeen. In the past nine months, several dozen single crystals of lithium fluoride containing different amounts of the isotopes lithium-6 and lithium-7 have been grown there.

Most of the specimens have been slender rods for thermal conductivity measurements, but plates from 1-in. diameter crystals have recently been tested in the infra-red. The results illustrate the effect of a variation in the reduced mass $\overline{M}$ on the infra-red dispersion frequency ω_0. In the notation used by Born and Huang[1],

$$\frac{K}{\overline{M}} = \omega_0{}^2 \left\{\frac{\varepsilon_0 + 2}{\varepsilon_\infty + 2}\right\}$$

Hence, if the force coefficient K and the dielectric constants ε_0, ε_∞ are unchanged by the isotopic substitution, then $\overline{M}\omega_0{}^2$ is constant and $\omega_0 \propto (\overline{M})^{-\frac{1}{2}}$. The reduced masses for ^{6}LiF and ^{7}LiF are 4·570 and 5·125, respectively, and so the infra-red dispersion frequencies ω_0 should be in the ratio $\frac{\omega_0(6)}{\omega_0(7)} = 1{\cdot}059$.

A crystal containing 90 per cent of ^{6}LiF was compared with another containing 95 per cent of ^{7}LiF. Here a frequency ratio 1·051 : 1 is obtained by linear interpolation. Reflectivity data for the short-wave end of the rest-strahlen band is shown in Fig. 1. A Hilger double-beam spectrometer with a potassium bromide prism was used, and the radiation was incident at 20° to the normal on a polished (100) surface. Tests for scattered light were made with barium fluoride and cadmium fluoride filter plates. At wave numbers below 450 cm.$^{-1}$ a considerable correction was required, but above 500 cm.$^{-1}$ the effect was small. The data were scaled by direct substitution of a heavily aluminized optical flat for which 97 per cent reflectivity was assumed.

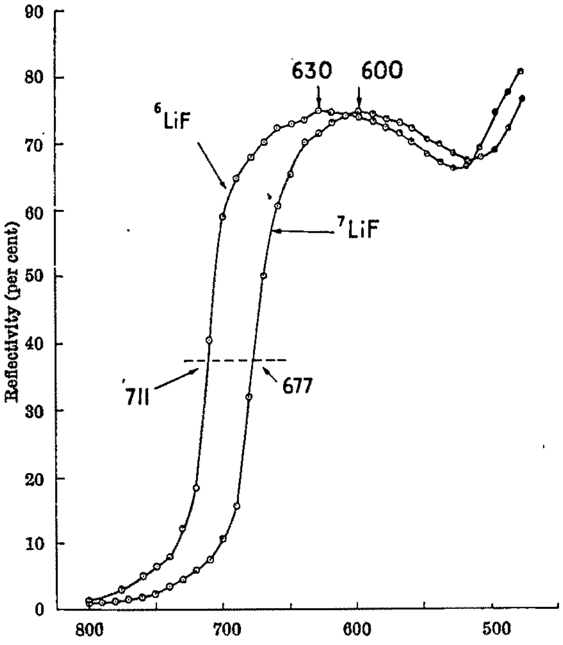

Fig. 1. Variation of reflectivity with wave number

The lithium fluoride band has a subsidiary shortwave peak as described by Hohls[2]. This peak occurs at 630 cm.$^{-1}$ for the ^{6}LiF-rich crystal, and at 600 cm.$^{-1}$ for the ^{7}LiF-rich crystal, giving the expected frequency ratio 1·05 : 1. For both specimens the reflectivity at the subsidiary peak was 75 per cent. A further test can be made in the steeply rising section of the curve by comparing the wave-numbers at which reflectivity reaches 37·5 per cent, that is, one-half of the subsidiary peak value. This occurs at 711 cm.$^{-1}$ for the ^{6}LiF-rich crystal and at 677 cm.$^{-1}$ for the other. The ratio is again 1·05 : 1.

Assuming that the sudden rise in reflectivity occurs in the neighbourhood of the longitudinal lattice frequency ω_L, then ω_0 can be derived from:

$$\omega_0{}^2 = \left\{\frac{\varepsilon_\infty}{\varepsilon_0}\right\} \omega_L{}^2$$

Since for lithium fluoride $\varepsilon_0 = 9{\cdot}27$ and $\varepsilon_\infty = 1{\cdot}92$ the wave number equivalent to ω_0 should somewhat exceed 324 m.$^{-1}$ for pure ^{6}LiF and be somewhat less than 308 cm.$^{-1}$ for pure ^{7}LiF.

The useful transmission limit of an alkali halide crystal also varies in proportion to the rest-strahlen frequency. Fig. 2 shows the absorption coefficient k in cm.$^{-1}$ for the two concentrations. The ^{6}LiF-rich crystal reaches an absorption $k = 1$ cm.$^{-1}$ at a wave number 1,634 cm.$^{-1}$ and the ^{7}LiF at 1,542 cm.$^{-1}$. Here the ratio is 1·059 : 1.

The ^{6}LiF crystal was spectroscopically pure. The main impurities in the ^{7}LiF crystal were $0{\cdot}6 \times 10^{-2}$ per cent of tin and $1{\cdot}2 \times 10^{-2}$ per cent of carbon. Measurements on the refractive indices of the two materials are being made.

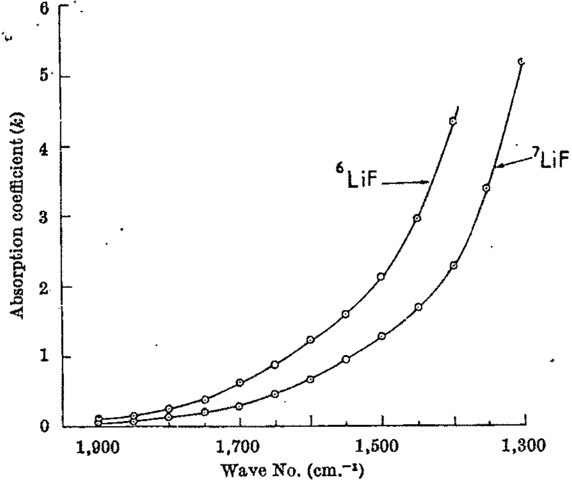

Fig. 2. Variation of absorption coefficient with wave number

We wish to thank the Ministry of Supply for a grant providing the crystal-growing facilities in the Natural Philosophy Department at Aberdeen, and the Chemical Services Department, Capenhurst Works, United Kingdom Atomic Energy Authority, for preparing and analysing the lithium fluoride.

We also thank Dr. D. C. McKean, of the Chemistry Department, Aberdeen, for the loan of a spectrometer equipped for this range, and Mr. W. Mitchell for assistance in the construction and operation of furnaces.

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X-Ray Study of Rare Phosphate Minerals

A RARE phosphate mineral assemblage is found in an abandoned mica pegmatite in Sorhee mica mine, north of Laldaiya Pahar (24° 47′ N., 86° 10′ E.; Survey of India, Sheet 72 *L*/1), Monghyr, Bihar. The main pegmatite, worked over a zone of about 200 ft. with a width of nearly 130 ft., intrudes schistose rocks striking N. 25° W. with a dip of about 60° towards W.S.W. The rare phosphate minerals occur as an aggregate, forming bands sometimes more than 2 in. wide and 8 in. long, veined with quartz. The X-ray powder diffraction study shows that the phosphate assemblage consists of graftonite (pale pink) and triphylite (bluish green) with traces of heterosite (purple). A brown mineral, the powder pattern of which is identical with that of rhodonite (manganese silicate), and an unidentified black mineral with rhodochrosite, pyrolusite, hæmatite and amorphous admixtures are also associated in the assemblage.

Penfield[1] first described graftonite, in coarsely laminated intergrowth with triphylite, from a pegmatite near Grafton, New Hampshire. The X-ray single crystal data and powder-spacing data of graftonite, found associated with arrojadite in nickel plate pegmatite, S. Dakota, were reported by Lindberg[2]. Bjorling and Westgren[3] and also Gossner and Strunz[4] gave single-crystal data of triphylite from Varutrask and Hagendorf. Heterosite occurs as a secondary phosphate mineral, formed by the oxidation of triphylite[3,5]. A black lustrous mineral[5,6] occurs as an alteration product of the phosphate minerals, but no detailed examination of this mineral was made.

The unit-cell dimensions (Table 1) were obtained from sets of rotation and zero-layer Weissenberg photographs of a small cleavage fragment of graftonite about the three crystallographic axes. The powder spacing data of this graftonite are identical with those of Rice pegmatite, New Hampshire, and differ considerably from those of Lindberg's nickel plate pegmatite, S. Dakota. The spectrum analysis of this graftonite shows mainly iron, manganese, calcium and phosphorus with small amounts of magnesium, aluminium, nickel, copper, sodium and potassium and traces of lithium, cobalt and tin. Lindberg's chemical analysis of graftonite shows mainly iron, manganese, calcium and phosphorus with small amounts of sodium, aluminium, magnesium and lithium (no potassium) and traces of tin, zinc and copper. The unit-cell dimensions (Table 1) were obtained from sets of rotation and zero-layer Weissenberg photographs about two crystallographic axes of a small cleavage fragment of pale blue triphylite, which is usually unfavourable for single crystal work.

Table 1

	Cell dimensions (A.) a_0	b_0	c_0	Axial angle β (deg.)	Axial ratios $a_0:b_0:c_0$
Graftonite					
Mica-pegmatite (Monghyr, Bihar)	8·89	11·57	6·16	99° 6′	0·768 : 1 : 0·532
Nickel-plate pegmatite (South Dakota) (ref. 2)	8·87	11·57	6·17	99° 12′	0·766 : 1 : 0·533
Triphylite					
Mica-pegmatite (Monghyr, Bihar)	6·02	10·36	4·72		0·581 : 1 : 0·455
Varuträsk (ref. 3)	*6·04	10·37	4·71		0·582 : 1 : 0·454
Hagendorf (ref. 4)	*6·00	10·34	4·67		0·580 : 1 : 0·452

* kX.

The powder-spacing data of the purple mineral were found to be identical with those of heterosite from Varutrask pegmatite[3]. The powder-spacing data of the brown mineral correspond almost exactly with those of rhodonite (manganese silicate)[7]. The powder photograph of the dark brown and black mineral grains records faintly the powder lines of rhodochrosite ($MnCO_3$)[8], pyrolusite (MnO_2), hæmatite and a strong broad band or halo, which is characteristic of amorphous admixture associated with cryptomelane; but the powder-spacing data of the main constituent in the black mineral grains do not correspond with those of cryptomelane or of any known manganates or manganese-oxide minerals. The spectrum analysis of the black mineral grains associated with dark brown mineral and traces of quartz shows mainly manganese and iron with considerable amounts of silicon, magnesium, aluminium, calcium and phosphorus, small amounts of potassium, sodium, and copper and traces of vanadium, nickel, silver and platinum (no lithium).

Grateful acknowledgment is made to the Director for kind permission to publish these results, to Dr.

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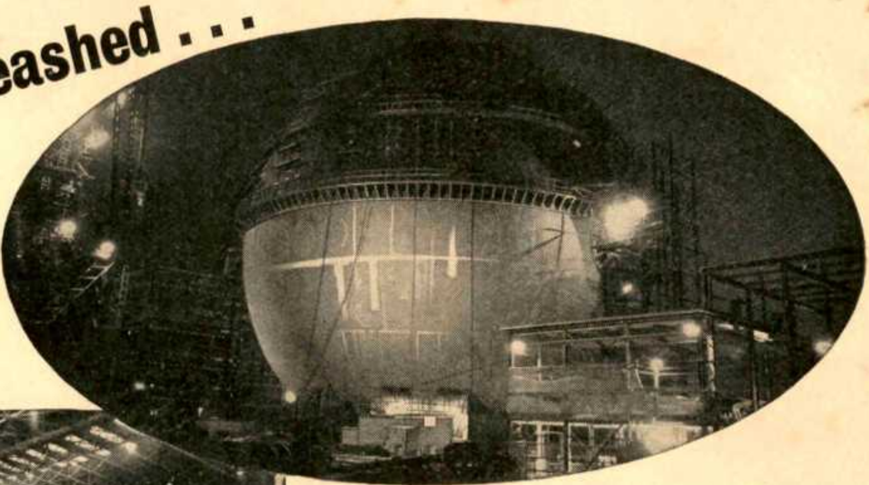

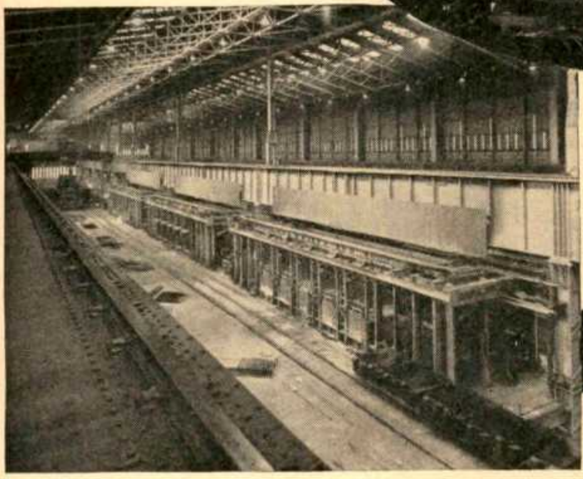

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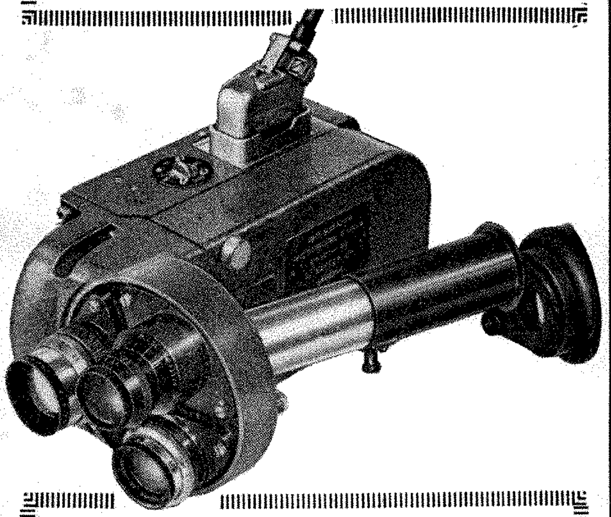

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A. G. Jhingran for valuable discussion and to Dr. A. P. Subramaniam for initiating this investigation.

B. Mukherjee
U. Prasad

Geological Survey of India,
Calcutta.

June 9.

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Cultivation of Apple-fruit Tissue *in vitro*

The *in vitro* culture of meristematic tissues derived from roots, tubers, stems, galls and tumours has received much attention, but little is known of the growth requirements of tissues of mature parenchymatous fruit walls (for a definition of the latter term, see ref. 10). The only two tissues of this type which appear to have been cultured are mature avocado pericarp[1] and mature citron mesocarp[2]. In the former tissue active cell division is occurring, but it is unlikely that many cells of the latter tissue are dividing[3]. In the developing apple-fruit, cell-division is completed within 20 days after fertilization, and subsequent growth is due entirely to cell enlargement[4]. In this report the *in vitro* cultivation of tissue derived from apple-fruits both before and after cessation of cell division is described. This appears to be the first successful *in vitro* cultivation of a pome-fruit tissue.

Surface-sterilized fruitlets (diameter *c.* 10 mm.; about 15 days from fertilization) of the varieties Sturmer Pippin, Granny Smith and Cox's Orange Pippin were cut into three pieces by two parallel transverse cuts. The entire centre pieces (thickness 2 mm.) were seated aseptically on agar media (0·5 per cent of Davis agar) with one cut surface contacting the medium. Neither White's medium[5] nor White's medium supplemented with coconut milk induced growth from Sturmer explants. On White's medium[5] supplemented with cysteine 10 p.p.m., calcium pantothenate 0·2 p.p.m., inositol 0·2 p.p.m., biotin 0·2 p.p.m., 2,4-D (2,4-dichlorophenoxyacetic acid) 6 p.p.m., and coconut milk at 10 per cent by volume, explants of all three varieties grew actively. A large number of centres of proliferation developed on the cut surface of cortex and pith. The new tissue has been subcultured and maintained in growth by the liquid-culture technique of Caplin and Steward[6].

Tissue from relatively mature fruits has also been cultured. Disks of tissue (thickness × diameter, 2 mm. × 7 mm.) were excised aseptically from near the equatorial plane of surface-sterilized fruit (variety Sturmer Pippin, 110–130 days from fertilization) so that a sepallary or petallary vascular bundle ran centrally through each explant. The growth-rate of these explants was more than ten times the rate of growth of identically excised explants from the mid-cortex and mid-pith. The medium previously used for the cultivation of fruitlet tissue with the 2,4-D concentration reduced to 1 p.p.m. induced active growth on the surface of nearly all explants. The corresponding medium without coconut milk (medium 1) induced only very slight proliferation on approximately 35 per cent of the explants, the remainder showing no growth. The addition of *l*-asparagine to medium 1 (resulting concentration 150 p.p.m.), yielding medium 2, was slightly stimulative, but no detectable stimulation was produced by the addition of pancreatic digest of casein to medium 1 (resulting concentration 200 p.p.m.), or by doubling the nitrate content of medium 1. A marked stimulation of growth was observed in each case when coconut milk, aqueous extract of immature maize seed or 6-furfurylaminopurine was added individually to medium 2 to give concentrations of 10 per cent by volume, 850 p.p.m. of total solids and 0·2 p.p.m. respectively. Addition of casein hydrolysate to medium 2 did not significantly increase the growth-rate of explants. The further addition of gibberellic acid and 2-benzthiazolyloxyacetic acid (both at three concentrations) did not produce any significant effect.

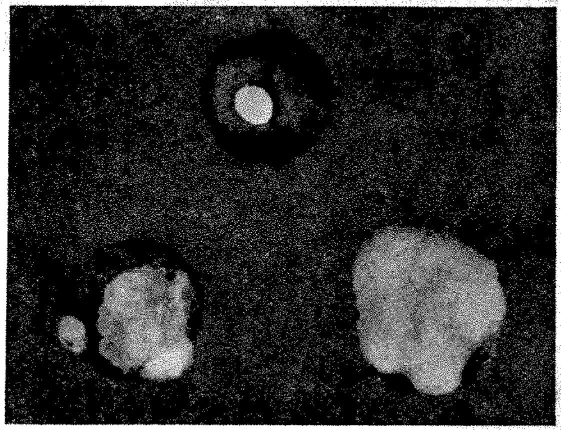

Fig. 1. Sturmer-Pippin explants (excised 110 days from fertilization and cultured on agar media) showing the development of growth from the vascular bundle

The response from coconut milk was probably due to the specific factors present in this fluid which stimulate cell division. If the increased growth-rate was merely due to the presence of additional amino-acid nitrogen, a response to casein hydrolysate might have been expected[7,8]. Removal of 2,4-D from medium 2 supplemented with coconut milk yielded an almost inactive medium. Sturmer apple tissue therefore responds to coconut milk only in the presence of 2,4-D (the effects of other auxins have yet to be investigated). Potato-tuber tissue also has this unusual double requirement for growth *in vitro*[9]. Avocado pericarp and citron mesocarp appear to proliferate *in vitro* without stimulants of the type found in coconut milk[1,2].

The growth of new tissue in culture was mainly from the cut surface of the vascular bundle on the centre of the explant (see Fig. 1). Less active centres of growth sometimes developed on the surface of the explants but their contribution to the total growth was usually small. The new tissue had a white appearance resembling carrot tissue grown on solid media, and was composed of very small cells, about 1/70 of the volume of the explant parenchyma cells. The following varieties, when within 1–3 weeks of maturity, have been cultured on medium 2 supplemented with coconut milk or on this medium with the 2,4-D concentration at 5 p.p.m.; Prince Alfred, Ben Davis, Jonathan, Delicious, Statesman, Dunns and Giant Geniton. Crab-apple tissue (95 days after fertilization) has been cultured on medium 2 supplemented with coconut milk, centres of proliferation being induced on the transversely cut surface of both pith and cortex. Undifferentiated growth has also been obtained from immature seed tissue.

A detailed investigation of the cultivation of apple tissue *in vitro* is in progress. The work reported has been assisted by a grant from the Rockefeller Foundation. Thanks are also expressed to Dr. H. R. Thompson for statistical analyses, to Miss D. A. Bridson for technical assistance, to the American Cyanamid Company for a generous gift of 2-benzthiazolyloxyacetic acid, and to Imperial Chemical Industries, Ltd., for a gift of gibberellic acid.

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Temperature Variations in Male Cones of *Encephalartos*

In the hope that this may elicit more information than I have been able to find in the available literature, I give below a summary of observations made on the diurnal rise and fall of temperature in ripe male cones of *Encephalartos altensteinii* Lehm. and *E. lehmannii* Lehm.

Cones cut from plants of *E. altensteinii* growing in the Botanic Gardens, Grahamstown, were used for demonstration purposes during the course of practical work for students of botany, and reference was made to the fact, known to me since childhood, that such male cones, when ripe, become heated. Search of the literature available produced only one reference to this phenomenon[1], in support of my statement, and a rough test was therefore made on a cone to show the truth of the assertion. A thermometer, registering 21° C. in the laboratory, was inserted between the sporophylls of the male cone at a part which was obviously the warmest to the hand: within a matter of seconds, this thermometer registered 35°. During the course of the afternoon, the thermometer registered a rise to 37° (as against an air temperature of 20°) within the cone. This cone was at the stage of shedding pollen and had been removed from the parent plant two days before, being kept on a laboratory bench meanwhile. When discussion with workers whose knowledge of the genus *Encephalartos* is greater than mine, showed that this temperature rise was unknown to them, further rough tests were made on several cones.

These preliminary tests soon showed that besides this remarkable rise in temperature there is a diurnal rhythm, the temperature of the cones rising from about eleven or twelve o'clock in the day, to a maximum about five o'clock in the afternoon, and then falling again until it is the same as, or very close to, the air temperature of the room. The tests were carried out with several cones over a period of several days in the laboratory, and a set of fresh cones was obtained, which gave the same results.

As these were observations made on cones cut from the plant, male cones still *in situ* were also tested. These also showed a great temperature rise and difference between the air temperature and that of the cones, during the afternoon hours.

Tests made on *E. lehmannii* Lehm. do not show the same great rise and fall, but there is apparently some rise of temperature in male cones of this species also. Cones of *E. villosus* were also tested but these were rather far advanced: also, the cones are more open in structure and, perhaps for these two reasons, no results were obtained showing any rise.

A fuller account of these facts will be published later, but if any workers on the Cycadales have information on such a rise of temperature in male cones or know of references in the literature to this fact, apart from the one I have given, their help will be appreciated. It is certainly true, as Gaussen says, that "le cône présente une veritable fièvre", and it would seem that there must be more information either published or known.

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Root Nodules of *Coriaria*

The shrubby genus *Coriaria* is one of the eight non-legume Angiospermous genera known to have the capacity of forming root nodules in response to infection from the soil by a symbiotic organism. In some instances, in confirmation of earlier work, the nodules of most of these genera have been shown by my collaborators and me[1,2] to be nitrogen-fixing, but, despite efforts extending over several years, I have not yet raised nodulated plants of *Coriaria* in culture, owing to an apparent difficulty in securing infection of the roots under artificial conditions. However, the results of Kataoka[3] make it probable that *Coriaria* nodules also are nitrogen-fixing.

As pointed out by Good[4] this genus is at present characterized by extreme 'discontinuity' in the sense that it occurs in widely separated regions, chiefly Japan, New Zealand, the Mediterranean region, and Central and South America. So far as I am aware it is only in respect of Japan that records of nodulation in *Coriaria* are to be found in the literature[5]. From correspondence with New Zealand botanists and from material gratefully received from them it is clear that nodulation occurs in that country also. Despite the attention paid by earlier European botanists to the presence of nodules in *Alnus*, *Hippophaë* and *Elaeagnus*, there seems no previous record of the inspection for nodules of the roots of *Coriaria* species native to Europe. Through the good offices of Mr. N. Y. Sandwith, of the Royal Botanic Gardens, Kew, inquiries were made of Dr. P. Montserrat, of Barcelona, with the result indicated in the following communication, which has been translated from the Spanish by Mr. Sandwith.

It has been suggested elsewhere[6] that the geochemical significance of fixation by non-legume nodules must not be overlooked. For example, in New Zealand, which is recognized as deficient in native legumes, the widespread species of *Coriaria* are possibly the main native source of symbiotically fixed nitrogen. The present discontinuous distribution of the genus, noted above, probably indicates that in former times the genus was represented in many regions from which it has now disappeared, and was thus in a position to contribute to the supply of combined nitrogen for plant life in general in many areas.

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Coriaria myrtifolia, the only species of the genus occurring in the western Mediterranean region, is extraordinarily abundant in the less dense woodlands of the Spanish provinces of Gerona and Barcelona (eastern part) at altitudes of 200–600 m., reaching occasionally to 1,000 m. and also descending in gullies to sea-level. It is more localized in the provinces of Lérida and Tarragona, and rare in more southerly provinces. It occurs, but is not now regarded as native, in Portugal[1]. The species reappears in the western Rif and Algeria, and also in the island of Ibiza[2], while in southern France it extends from the Gironde to the Alpes Maritimes, penetrating into Italy as far as part of the Apennines. Its occurrence in Sicily and Greece is doubtful.

On examining the root systems of young plants of *C. myrtifolia* in two localities, in the provinces of Barcelona and Lérida respectively, clearly evident root nodules were observed, resembling closely those described for Japanese material[3] and others shown in photographs provided by Dr. Bond of New Zealand material. Difficulty was experienced in locating the nodules on old plants.

It may be added that the species attains its optimal development in the humid climates where *Quercus ilex* is dominant. It prefers strong clay soils and is markedly heliophilous, being found especially along the borders of roads, streams and woodland; it is commonly associated with *Prunus spinosa* and species of *Rubus* and *Clematis*, and de Bolós[4] has provided a full ecological study of the *Rubeto–Coriarietum* association.

The fertility of soils where *C. myrtifolia* occurs plentifully is an accepted fact. In some evergreen oak woods the species makes a complete ground cover, and could be of some importance in forest economy if appreciable fixation of nitrogen occurs in the root nodules. It may be noted that thousands of tons of leaves of *C. myrtifolia* were formerly collected each year for use in tanning leather.

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Fluorescent Pigment of *Microsporum*

In a previous communication, Wolf[1] reached the conclusion that the fluorescent pigment produced by *Microsporum canis* Bodin and *M. gypseum* Guiart and Grigorakis was a pteridine. The fluorescent substance was extracted from cultures of both fungi grown *in vitro* upon hair and on a synthetic medium. The conclusion as to the pteridine nature of the pigment was based upon ultra-violet absorption spectra, fluorescence spectra, and paper chromatography of a purified material, and is consistent with the results of earlier chemical studies[2,3].

Since then, Chattaway and Barlow[4] have challenged this conclusion, without however adding any new evidence, and have raised questions concerning the nature of fluorescent materials in uninfected hair and in naturally infected hair which neither they nor ourselves can answer at the present time. Recently, Rebell *et al.*[5] have shown that the fluorescent material of rat hair is *l*-kynurenine, but the nature of the fluorescent substance in human hair has not been established. It is the purpose of this communication to present additional evidence as to the pteridine nature of the *Microsporum* pigment derived from infra-red studies and bioassay.

Cultures of *Microsporum canis* and *M. gypseum*, grown upon hair and upon a synthetic medium, were extracted with water by autoclaving for 15 min. The fluorescent material was adsorbed on charcoal, eluted with methanol, and passed through a column of alumina as previously described[1]. The methanol extracts were evaporated to dryness, and potassium bromide pellets containing the fluorescent substance were examined in the infra-red with a Perkin–Elmer model 21 spectrophotometer. The spectra are shown in Fig. 1.

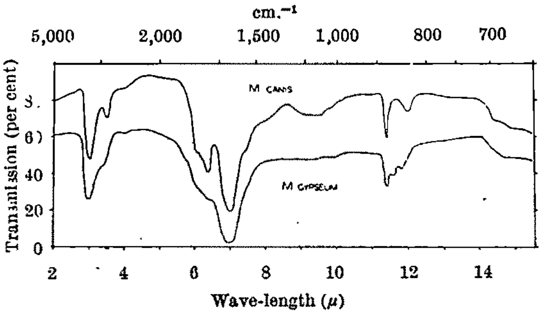

Fig. 1. Infra-red absorption spectra of the fluorescent pigments of *Microsporum canis* and *M. gypseum*

For *M. canis*, the absorption maxima found were as follows: there was a large peak at 3,375 cm.$^{-1}$, indicating an —OH or an =NH group, a small peak at 2,875 (possibly C—H), a shoulder at 1,700 (—CONH$_2$), a medium peak at 1,580 (—NH$_2$), a large peak at 1,440 (possibly C—H), a shoulder at 1,380 (—CONH$_2$), a broad peak at 1,040–1,100 (—NH$_2$), a large peak at 880 and a small one at 840 cm.$^{-1}$ (both of C—H).

The spectrum for *M. gypseum* was quite similar. There was a large peak at 3,375 cm.$^{-1}$, a shoulder at 2,950, a shoulder at 1,580, a large peak at 1,440, a shoulder at 1,350, a large peak at 880 and small peaks at 865 and 855 cm.$^{-1}$. The relatively small number of peaks appears to us to refute the objection of Chattaway and Barlow[4] that our methods of preparation "would almost certainly not effect any great purification of the fluorescent material", and further indicate that our preparations had a purity

Table 1. Crithidia Factor Activity of *Microsporum* Preparation-Growth expressed as Optical Density

Additions	Alone	Folic acid added (1·0 μgm./ml.)	Pteridine added* (1·0 μgm./ml.)
None	0·08	—	–
Folic acid (1·0 μgm./ml.)	0·10	—	0·85
Pteridine* (1·0 μgm./ml.)	0·10	0·86	—
M. gypseum preparation (0·001 ml./ml.)	—	0·44	0·10
(0·01 ml./ml.)	—	0·84	0·10

* 2-NH_2, 4-OH, 6-trihydroxypropyl pteridine was used here as a source of Crithidia factor.

greater than those examined by Robinson, Figge and Bereston[6] in their infra-red studies of the fluorescent material from *M. audouini*.

Biological verification of the pteridine nature of the compound from *M. gypseum* was obtained by microbiological assay with *Crithidia fasciculata*, a flagellate which requires for growth both a conjugated and an unconjugated pteridine[7]. The finding that preparations from *M. gypseum* possess growth-factor activity for *C. fasciculata* in the presence of low levels (1·0 μgm./ml.) of folic acid, but not in the presence of 'Crithidia factor' (2-NH_2, 4-OH, 6-trihydroxypropyl pteridine) indicates that the compound from *M. gypseum* is an unconjugated trisubstituted pteridine (Table 1). The substituents may be 2-NH_2 or —OH, 4-OH and 6-CH_2OH or a longer aliphatic chain which has two vicinal hydroxy groups. Three of the possible biologically active compounds, 2-NH_2, 4-OH, 6-trihydroxypropyl pteridine[8], compound *A* of Forrest and McNutt[9], and compound *C* of Van Baalen *et al.*[10] are ruled out because of differences in infra-red spectra.

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Experimental Ringworm in Guinea Pigs: Oral Treatment with Griseofulvin

In an effort to find a satisfactory agent for the topical treatment of ringworm and other superficial mycoses, many substances, including antibiotics, have been investigated in the past. Although high anti-fungal activity has often been demonstrated by tests *in vitro*, such compounds have given disappointing clinical results when applied topically, and it is now recognized that this is probably due to the inability of such substances to penetrate the keratin of skin, hair and nails to the site of dermatophyte activity. For this reason it has often been suggested that the eventual curative agent will be administered systemically. Wilson[1] states that "the ideal anti-fungal drug even for superficial mycoses would seem to be one which could be safely administered internally in amounts sufficient to endow the cells eventually destined to produce keratin with the power to resist fungi completely, this power persisting as they become keratinized, and the drug thus exerting its effects from within outward".

So far as I am aware there is only one published report of ringworm treatment by systemic means[2] and therefore the following preliminary account of successful treatment of experimentally induced ringworm in animals by oral administration of the antibiotic, griseofulvin, is of interest.

Griseofulvin, a metabolic product of several *Penicillium* species[3], is markedly fungistatic to many fungi *in vitro*[4] and in plants shows systemic antifungal activity[5]. Although little is known about the absorption of griseofulvin when given by mouth, it is reported to have a low mammalian toxicity and it seemed worth while investigating for possible systemic activity in animals.

Guinea pigs were infected experimentally with *Microsporum canis* and treatment with griseofulvin was commenced 10 days later when the lesions were well developed and fluoresced under Wood's light. The antibiotic was administered daily by mouth at a dosage of 60 mgm./kgm.; control animals were given unmedicated tablets. The beneficial effect of treatment was evident clinically within four days of the administration of the first dose of griseofulvin and the highly inflammatory reaction which developed in all the control animals was prevented. Clinical findings were confirmed by killing animals from both the treated and the control group to permit histological examination. In the group treated with griseofulvin about half the hair follicles were infected after four treatments and by the eighth treatment infected follicles were present only very infrequently. Skin sections of the untreated group at these times showed that almost all the hair follicles were heavily invaded by the dermatophyte. It was noted that under Wood's light the infected hairs of treated animals fluoresced only at the tips, and microscopic examination revealed that the dermatophyte was present only in this upper part of the hair shaft. The uninfected basal portion was sharply delimited from the invaded part and malformation of the tips of the dermatophyte hyphæ, characteristic of the effect produced by griseofulvin on susceptible fungi, was seen in a number of hairs cut longitudinally in skin sections. It seems clear that the uninfected part of the hair had been formed during the treatment with griseofulvin and was resistant to invasion by the dermatophyte.

By similar experiments I have found that griseofulvin is equally effective when given orally to guinea pigs experimentally infected with *Trichophyton mentagrophytes*, and it has also been used successfully for the treatment of *T. verrucosum* ringworm induced in cattle[6]. *In vitro*, it is active in low concentrations against all the common dermatophytes.

Further studies are in progress and will be reported elsewhere, together with full details of these preliminary findings. The purpose of this communication is to make available experimental results which may be of some importance for future progress in this hitherto unrewarding field of investigation.

I am indebted to Miss C. O. Dawson, Miss M. Mennie and Miss M. Calder for assistance and to Glaxo Laboratories, Greenford, Middlesex, for supplies of griseofulvin and pharmacological information.

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Geographical Colour Polymorphism and Chromosome Constitution in Sympatric Species of Sawflies

The taxonomy of the *arcuata-schaefferi* group of *Tenthredo* sawflies has been a matter of interest both on the Continent[1] and in Britain[2] [3] for some considerable time. The adults are strikingly similar and interspecific differences can be discerned in the females only. Good descriptions of larvæ have not been available for some of the species, and existing accounts in some cases appear vague and confusing, so that doubt exists as to whether reported differences are of inter- or intra-specific rank.

For some time now three members of this group have been the subject of extensive breeding experiments at Queen's College, Dundee, and a full account of the life-histories from egg to adult is now available. Much that is interesting has resulted from this work and some of the facts readily explain previous difficulties in larval identification. Thus it appears that larval colour polymorphism exists in two of the species, namely, *Tenthredo acerrima* Benson and *T. perkinsi* Morice. This polymorphism operates on a simple genetical basis and is related to certain geographical areas of the British Isles. Similarly, in *T. acerrima* intra-specific physiological differences revealed by examination of locomotory activity have resulted in interesting information on the geographical and genetical aspects of such differences.

It has proved impossible to hybridize *T. acerrima* Benson, *T. perkinsi* Morice and *T. arcuata* Forst, and in fact copulation has not been observed although there was ample opportunity for it to occur. Host-plant preference is marked but not absolute, *T. arcuata* and *perkinsi* being associated with white clover (*Trifolium repens* L.) and *T. acerrima* with bird's-foot trefoil (*Lotus corniculatus* L.). The colour and markings of *T. acerrima* larvæ are clearly different from those of either *T. arcuata* or *perkinsi*. In the penultimate instar, however, the larvæ of the last two species resemble each other somewhat, so that it is pleasing to find that there are cytological differences. In *T. arcuata* the male larvæ produced parthenogenetically have a haploid number of 15 chromosomes, whereas female larvæ have a diploid number of 30, but *T. perkinsi*, on the other hand, possesses a haploid number of 18 and a diploid number of 36. Biological, morphological and cytological evidence thus combine to suggest specific rank for these three insects.

In at least one very local and limited area, however, the species *T. acerrima* appears to be variable cytologically as well as morphologically and physiologically. While several *acerrima* larvæ show a haploid chromosome number of 18 and a diploid number of 36, members of one particular brood gave counts of 21 and 42 respectively, possibly the highest number recorded in Tenthredinidae. Inter-breeding of this aberrant brood with 'normal' individuals from the same area gave viable offspring with intermediate chromosome counts. The 'aberrant' and 'normal' parents, taken in the field from the same ecological area, resembled each other in appearance, and the resulting broods of intermediate chromosome count also appeared very similar. It is interesting therefore to find that a survey of the locomotory activity of these same broods showed that they differed in behaviour from what had previously been considered normal for the wild types taken in the area.

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Different Frequencies of Supernumerary Chromosomes in Diploid Populations of *Dactylis glomerata* in Israel

Whether supernumerary chromosomes have any selective advantage is still in doubt[1-3]. One possible way of attacking this problem is to find out whether natural populations of a given species show different frequencies of such accessory chromosomes in different ecological habitats.

Dactylis glomerata L. offers favourable material for such an examination. Both diploid ($2n = 14$) and tetraploid ($2n = 28$) forms of this group occur in Israel, where they occupy a rich variety of ecological niches. In diploid plants supernumerary chromosomes of standard size and form are frequently encountered.

Three diploid populations were examined as to the frequency of supernumerary chromosomes in them. In each case, a sample of plants was taken at random in the early winter of 1958, transferred to Jerusalem and examined in the spring. Chromosome counts were made at diakinesis and metaphase I in aceto-carmine squashes of pollen mother cells. The results of this examination are given in Table 1.

The Safad sample was taken from a population growing on the northern outskirts of Safad, Upper

Table 1. Frequency Distribution of Supernumerary Chromosomes in Three Diploid Populations of *Dactylis glomerata* L. in Israel

Locality	Total No. of plants examined	No. of supernumeraries 0	1	2	3	4	Supernumeraries per plant	Supernumerary carriers (per cent)
Safad	75	37	24	11	3	–	0·73	50·70
Mount Kenaan	31	23	5	1	2	–	0·42	25·80
Jerusalem	80	57	20	2	1	–	0·34	28·75

Galilee. The plants were growing on a steep north facing slope, altitude 750 m., and on light Rendzina soil derived from chalky Senonian bedrock.

The Mount Kenaan sample was collected approximately 2 km. north of Safad. This place is characterized by terra-rossa soil on hard Eocene limestone. Plants were taken from the top of a hill, altitude 950 m.

The Jerusalem sample was collected in the Valley of the Cross (Matzleva) on the western outskirts of the city. Plants were growing on a gentle slope facing west, altitude 700 m., on terra-rossa soil derived from Upper Cenomanian dolomites and limestones.

The results indicate striking differences between Jerusalem and Safad populations. Most suggestive, however, is the comparison between Safad and Kenaan. Populations here are only 2 km. apart but found on completely different soils. At the 5 per cent level, the data indicate significant differences even between these two geographically close populations. (χ^2 test for homogeneity, plants with 2 and 3 supernumeraries grouped together: $\chi^2 = 6{\cdot}31$; $P \sim 0{\cdot}03$.) On the other hand, the Jerusalem and Kenaan populations seem very similar.

The examination suggests that *Dactylis* populations occupying different ecological habitats do differ from one another in regard to the frequency of supernumerary chromosomes. Such a difference could be attributed to different selective advantage of supernumeraries in different habitats.

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Spray-collecting Area of Locusts and their Susceptibility to Insecticides

LOCUST swarms may be sprayed with insecticides when the insects are settled or in flight. Techniques have been developed for the estimation of the amount of spray collected by individual locusts[1-4], and fundamental to their interpretation is the spray-collecting area of a locust. Two areas have been used for calculations: the plan area for settled locusts[1,2], reduced to allow for the less vulnerable parts, and the 'horizontal equivalent area' for flying locusts[3,4], defined as the horizontal plane area which, when passed through a given spray of droplets with the same velocity as a locust, collects the same number of droplets as the locust. The plan area of the desert locust, *Schistocerca gregaria* (Forsk.), is about 6½ cm.², and the horizontal equivalent area has been found experimentally to vary greatly with drop size, increasing from 30 cm.² for droplets 300μ in diameter to 450 cm.² for 50μ drops[5]. The collecting surface of a settled locust approximates to the plan area when the drops are falling nearly vertically, but at shallow angles of approach the quantity of spray deposited on the locust is many times that estimated from area dosage and plan area.

A development relating these parameters is the consideration of an area normal to the path of approach of the drops to the locust, the path of approach depending on the terminal velocity of the drops and the air-speed of, or wind-speed over, the locust. This 'normal equivalent area', a term suggested by Mr. K. F. Sawyer, may be defined as the area of a plane surface, at right angles to the path of approach of the drops, through which pass as many drops as are collected by the locust under similar conditions. Laboratory measurements of this area (see Table 1) can most easily be made by comparing the quantity of spray picked up by a locust with the quantity deposited on a sphere under the same conditions, due allowance being made for the droplet-collecting efficiency of the sphere.

Table 1. THE SPRAY-COLLECTING AREAS OF THE LOCUST (CM.²)

Settled locusts

Plan area for 10 males, 5·5; 10 females, 7·3. Normal equivalent area for randomly orientated locusts (spray droplets of 50–230μ and wind speed of 2 m./sec.) 5–6

Flying locusts

	Drop diameter (μ)			
	50	100	200–230	300
Horizontal equivalent area (ref. 5) (♂ and ♀)	445	110	46	31
Normal equivalent area (ref. 5) ♂	8·6	8·7	9·4	—
♀	9·9	11·0	11·2	—

In experiments with settled locusts, of unconstrained and variable orientation, the mean horizontal equivalent area was found to be 5–6 cm.² for uniform sprays from drops of 50, 100 or 230μ in diameter drifting over the locusts at 2 m./sec. At lower wind-speeds the values of the normal equivalent areas were reduced owing to a decreased collection efficiency of the locusts. For locusts flying through a falling spray, the normal equivalent area was found to be about 9 cm.² for males and 10½ cm.² for females, being virtually independent of the droplet diameter over the range 50–230μ.

The deposit on a locust from a uniform spray will be given by the product of the normal equivalent area, concentration, and path-length through the spray. The relative quantity of spray picked up by flying and settled locusts subjected to the same concentration of spray at the same relative wind speeds will be proportional to their normal equivalent areas. The flying locusts therefore collect nearly twice as much spray as the settled ones. Furthermore, the deposit on a settled locust can be expected to exceed the corresponding area dosage on a horizontal surface by a factor approximating to the cosecant of the angle of approach of the spray, measured from the horizontal.

When a 20 per cent solution of the insecticide 4 : 6-dinitro-*o*-cresol (DNC) in oil is sprayed over locusts, a decrease in size of the sprayed droplets from 300 to 100μ in diameter appears to cause an increase in the toxicity of the spray to both the flying and settled insects, as is shown in Table 2. The insecticide diazinon exhibits little change in toxicity with drop diameter when sprayed over flying locusts.

Table 2. *LD*50's OF INSECTICIDES SPRAYED ON TO *S. gregaria* (μgm./gm.)

Approximate drop diameter (μ)		50	100	215	300
Locusts settled	DNC	23*	25*	26*	35
	Diazinon	—	—	6·6*	—
Locusts flying	DNC	—	16	21	30†
	Diazinon	5·4	6·0	5·6	—

* Insects constrained to lie with long axis perpendicular to path of approach of the drops.

† Ref. 5.

Combining the differences in collecting area and susceptibility, the flying locusts are thus about 2·4 times as vulnerable to sprays of 4 : 6-dinitro-*o*-cresol solution as are settled ones and about twice as vulnerable to diazinon. The difference is further enhanced when the application of these results to a particular spraying operation is considered, owing to the wind gradient near the ground which effectively reduces the path-length of the settled locusts through the spray and may also reduce their normal equivalent areas. In actual field operations with aircraft, this increased vulnerability is, at times, more than counterbalanced by the low densities of flying swarms with consequent very low kills per gallon of insecticide.

I should like to thank Dr. R. C. Rainey and Dr. T. H. C. Taylor for their advice and encouragement during the preparation of this communication.

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Microscopic Structure of the Lungs of the Bottlenose Whale

One of the most remarkable structures in the lungs of Cetacea are the sphincters in the respiratory bronchioles. In a number of toothed whales (Odontoceti) the mucosa of these terminal bronchioles shows 8 to 40 consecutive ring-like folds with a circular layer of smooth muscle fibres acting as a sphincter. They may close the passage in the bronchiole completely. They divide the lumen in a number of small consecutive chambers. When the musculature relaxes the passage is re-opened by a system of radially directed elastic fibres, running from the muscular layer to the peripheral layer of cartilage. The sphincters have been described in the common porpoise (*Phocaena phocaena* (L.)), the bottlenose dolphin (*Tursiops truncatus* (Mont.)), the common dolphin (*Delphinus delphis* L.), *Prodelphinus caeruleo-albus* Meyen, the white whale (*Delphinapterus leucas* (Pallas)) and in *Berardius bairdii* Stejneger[1,4-9]. Several authors showed that these sphincters are not present in baleen whales (Mystacoceti)[2,6,7,9]. These animals show a very well-developed mass of muscular fibres in the tips of the alveolar septa. Probably these fibres are able to close the alveoles completely.

Murata[6] found a constriction in a respiratory bronchiole of the sperm whale (*Physeter macrocephalus* L.). This constriction was not found by other authors[2,9], and all agree that the typical system of consecutive sphincters is not present in the sperm whale. This fact suggests that the occurrence of the sphincters is not connected with the systematic position of the animals, but with functional aspects. The dives of whalebone whales and the sperm whale are deep and prolonged, and the animals have a lung capacity of about 50 per cent of that of the terrestrial mammals[3,7]. The other toothed whales do not dive very deep and very long. Their lung capacity is about 150 per cent of that of the land mammals.

To prove the above suggestion we studied the microscopic anatomy of the lungs of the bottlenose whale (*Hyperoodon ampullatus* (Forster)), a toothed whale characterized by deep and prolonged diving which has a very small lung capacity, like the sperm whale. Prof. J. T. Ruud kindly provided us with the lungs of an animal captured at the land station Steinshamn (Norway). The material was not very well preserved, but all essential characteristics could be determined.

As in all other Cetacea the connective tissue of the lungs was highly elastic. There was practically no lymphoid tissue. The bronchial epithelium and the glands contained almost no mucoid cells. These characteristics may be a result of the absence of dust in the aspired air[7]. The septa of the alveoles showed two layers of capillaries and many elastic fibres. As in Mystacoceti the tips of the septa contained a large amount of smooth musculature.

All bronchiæ showed a ciliary epithelium. At their outer side they were surrounded by a layer of irregularly shaped pieces of cartilage. This cartilage was also found in the terminal bronchioles as in all other Cetacea with the exception of *Berardius*[6]. On the inner side of the cartilage there is a layer of elastic connective tissue with a very distinctive plexus of anastomosing arteries. This arterial plexus is found even in the smallest bronchioles. The walls of the vessels are very elastic. *Delphinus* and *Phocaena* possess a venous or a capillary plexus[4,5]. The plexuses may act as shock-absorbers and they may also serve for heating the air.

At the inner side of the plexus is a very well-developed longitudinal layer of smooth musculature, as is the case in the terminal bronchioles. There are, however, no circular folds of the mucosa. Consequently the typical consecutive sphincters are absent in the bottlenose whale.

This phenomenon shows that the sphincters do not occur in animals characterized by deep and prolonged diving and of small lung capacity. They are found only in frequently breathing toothed whales with a large lung capacity. A system of consecutive cocks is used in technical constructions with great differences in pressure at either side of the cock. If the pressure must be regulated by opening the cock now and then, a series of consecutive cocks is preferable to a single one. It is highly probable that the system of sphincters must be considered as an adaptation to fluctuations of the air-pressure in the lungs during quick and frequent diving and emerging, and especially during the violent inspiration and expiration of Cetacea with a very large lung capacity.

J. R. Goudappel
E. J. Slijper

Netherlands Whale Research Group T.N.O.,
Zoological Laboratory,
University of Amsterdam.
June 10.

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APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Experimental Officer (male, under 28 on December 31, 1958, with a degree in forestry or botany with subsidiary chemistry, and an interest in ecology and Scottish woodlands), for work on forest ecology and management of woodland reserves in Scotland—The Nature Conservancy (E), 19 Belgrave Square, London, S.W.1 (August 22).

Lecturer (with a degree in botany or in agricultural botany, teaching and/or research experience, and preferably experience in genetics and plant breeding) in Agricultural Botany in the Department of Agriculture, Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 22).

Research Fellow or Senior Research Fellow in the Department of Pure Mathematics—The Registrar, The University, Birmingham 15 (August 22).

Senior Lecturer or Lecturer (with a degree in veterinary medicine, teaching and/or research experience, and preferably experience in a tropical country) in Veterinary Science in the Department of Agriculture, Kumasi College of Technology—The Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 22).

Senior Lecturer (with a good honours degree and teaching experience) in Applied Mathematics at the Nigerian College of Arts, Science and Technology—The Secretary, Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (August 22).

Head (well qualified in either chemistry or metallurgy and with appropriate teaching and industrial experience) of the Department of Pure and Applied Science—The Principal, The Chance Technical College, Crocketts Lane, Smethwick (August 23).

Senior Lecturer in Radiochemistry at the New South Wales University of Technology, Kensington, New South Wales, Australia—The Agent General for New South Wales, 56 Strand, London, W.C.2 (Australia, August 25).

Lecturer in the Department of Mathematical Physics—The Secretary, The University, Edinburgh (August 29).

Assistants (2) in Chemistry (one Inorganic and one Physical)—The Secretary, The University, Aberdeen (August 30).

Assistant Lecturer (with special qualifications in organic chemistry) in Chemistry—The Registrar, The University, Manchester 13 (August 31).

Biometrician with the Government of the Federation of Rhodesia and Nyasaland, for duties which will include design of experiments in all phases of agriculture and animal husbandry research and analysis of data and related statistical practice—The Secretary (*R*), Rhodesia House, 429 Strand, London, W.C.2 (September 7).

Assistant in Statistics—The Secretary, The University, Aberdeen September 12).

Lecturer (preferably with experience and interests in cytogenetics) in Botany at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 12).

Assistant Lecturer (with special qualifications in applied mathematics) in Mathematics—The Registrar, The University, Manchester 13 (September 15).

Lecturer or Assistant Lecturer in Geology at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 15).

Lecturer or Assistant Lecturer in Pharmacology at the University of Malaya—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 15).

Chair of Chemistry—The Secretary to the Curators of Patronage, The University, 4 Albyn Place, Edinburgh 2 (September 30).

Chair of Laryngology and Otology at the Institute of Laryngology and Otology—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 31).

Assistant Experimental Officer (with a degree in chemistry or agricultural chemistry or equivalent qualifications), to carry out chemical analyses of soils and plants; and an Assistant Experimental Officer or Experimental Officer, for biological work in connexion with the study of strains of insects resistant to insecticides—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Assistant, Grade B, in the Electrical Engineering and Physics Department, Coventry Technical College, to teach physics in National Certificate, Sandwich and Degree Courses to full-time, part-time day and evening students—Director of Education, Council Offices, Coventry.

Assistant Lecturer and Demonstrator in Physiology—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Assistant Warden (male, with a degree in zoology, and an interest in ornithology and marine or freshwater biology, and preferably some research experience) at Flatford Mill Field Centre; and a Field Assistant (female, with a university degree in geography or natural sciences)—The Secretary and Treasurer, Field Studies Council, Balfour House, 119–125 Finsbury Pavement, London, E.C.2.

Biologist (with postgraduate experience of experimental animal work), for cancer research—Prof. K. R. Hill, Pathology Department, Royal Free Hospital, London, W.C.1.

Head of the Bacteriology Department—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 58/23.

Organic and Physical Chemists, for research in the following fields: colloid chemistry of latex and related emulsions, polymerizations in emulsions and solid systems, mechanism of the ozonolysis of organic compounds and its control—The Director of Research, British Rubber Producers' Research Association, 48–56 Tewin Road, Welwyn Garden City, Herts.

Organic Chemist (honours graduate with Ph.D. or equivalent research experience, preferably in synthetic work), to join in research on biological action and molecular structure of organic compounds—Dr. C. J. W. Brooks, Clinical Chemotherapeutic Research Unit, Medical Research Council, Western Infirmary, Glasgow, W.1.

Reader in Mechanical Engineering, and a Reader in Electrical Engineering—The Principal, The Institute of Technology, Bradford 7.

Research Assistants (with a good honours degree), to carry out fundamental research in (*a*) problems in organic chemistry and (*b*) electronics, high vacuum problems or interferometry—The Clerk to the Governors, South-East Essex Technical College and School of Art, Longbridge Road, Dagenham.

Technical Research Assistant in the Physiology Department—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Technician (with experience in histological and photographic techniques, and preferably also in the general work of an anatomy department) in the Anatomy Department—The Secretary, Guy's Hospital Medical School, London Bridge, London, S.E.1.

REPORTS and other PUBLICATIONS

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

Ministry of Agriculture, Fisheries and Food. Domestic Food Consumption and Expenditure 1956: Annual Report of the National Food Survey Committee. Pp. iv+172. (London: H.M. Stationery Office. 1958.) 9*s*. 6*d*. net. [77

Bulletin of the British Museum (Natural History). Historical Series, Vol. 1, No. 5: The Gronovius Fish Collection: a Catalogue and Historical Account. By Alwyne C. Wheeler. Pp. 185–249+plates 26–34. 20*s*. The Culicine Mosquitoes of the Indomalayan Area. Part 3: Genus *Aēdes* Meigen, subgenera *Paraēdes* Edwards, *Rhinoskusea* Edwards and *Cancraedea* Edwards. By P. F. Mattingly. Pp. 61. 12*s*. (London: British Museum (Natural History), 1958.) [77

The Ninth Annual Report of the Wildfowl Trust, 1956–1957. Edited by Peter Scott and Hugh Boyd. Pp. 240 (32 plates). (London: Country Life, Ltd., 1958. Published for the Wildfowl Trust.) 10*s*. net. [77

Colonial Office. The Colonial Territories 1957–1958. Pp. xxv+171. (Cmnd. 451.) (London: H.M. Stationery Office, 1958.) 9*s*. net. [77

Department of Scientific and Industrial Research. Overseas Technical Report No. 4: Industrial and Economic Microbiology in North America. By A. W. J. Bufton. Pp. iv+37. (London: H.M. Stationery Office, 1958.) 2*s*. 6*d*. net. [77

Ministry of Power. Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1957. Northumberland and Cumberland Division. By H. Hyde. Pp. iv+41+6 plates. (London: H.M. Stationery Office, 1958.) 3*s*. 6*d*. net. [77

Other Countries

United States Department of Agriculture. Leaflet No. 161: The Eastern Tent Caterpillar. By B. A. Porter. Pp. 5. (Washington, D.C.: Government Printing Office, 1958.) [77

Publications de l'Institut National pour l'Étude Agronomique du Congo Belge. Série Scientifique. No. 71: *Helopeltis* du Cotonnier en Afrique Centrale. Par G. Schmitz. Pp. 178. 160 Belgian francs. No. 74: Géographie Humaine de la Région de Bengamisa. Par H. Beguin. Pp. 69. 60 Belgian francs. (Bruxelles: Institut National pour l'Étude Agronomique du Congo Belge, 1958.) [77

Deutscher Wetterdienst. Deutsches Meteorologisches Jahrbuch 1956. Pp. xxxvi+230. (Offenbach (Main): Deutscher Wetterdienst, 1958.) [77

Republic of the Sudan. Annual Report of the Government Analyst for the year 1956–57. Pp. 19. (Khartoum: Wellcome Chemical Laboratories, Ministry of Health, 1958.) [77

Carnegie Institute of Washington. Researches of the Department of Terrestrial Magnetism, Vol. 20 (Publication No. 175): Cosmic-Ray Results. Huancayo, Peru, January 1946–December 1955. Cheltenham, Maryland, March 1936–December 1955. Christchurch, New Zealand, January 1947–December 1955. Godhavn, Greenland, January 1947–December 1950. Pp. v+224. (Washington, D.C.: Carnegie Institution of Washington, 1957.) Paper, 2 dollars; Cloth, 2.25 dollars. [77

Naval Research Laboratory, Washington, D.C. NRL Report 5087: Upper Atmosphere Research Report No. 32: History of the Upper-Air Rocket-Research Program at the Naval Research Laboratory, 1946–1957. By J. W. Townsend, Jr., H. Friedman, and R. Tousey. Pp. ii+47. (Washington, D.C.: Naval Research Laboratory, 1958. Distributed by Office of Technical Services.) [87

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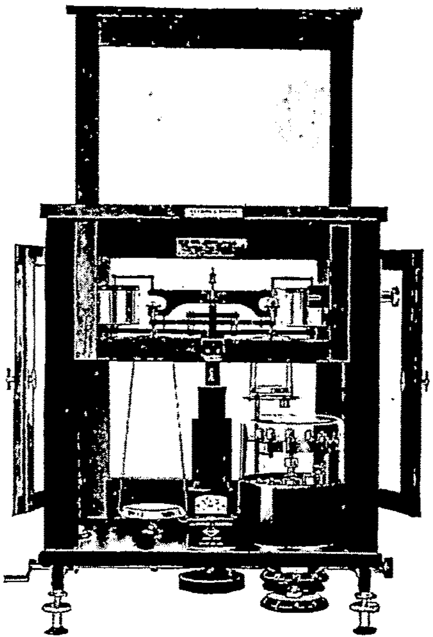

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A course of Lectures on ELECTRONICS will be held on Wednesday evenings from 6.30 to 8 p.m., commencing September 25, 1958. The course is suitable for those who wish to take this subject in the Graduateship examination of the Institute of Physics. Fee for the course: £2.

A Practical course on ELECTRONICS will be held on Thursday evenings from 6 to 9 p.m., commencing September 26, 1958. Fee for the course: £2.

A detailed syllabus of the lectures is available. Application to attend the course should be made as soon as possible to the Director of Education.

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SANDWICH COURSE IN CHEMISTRY

The Sandwich Course in preparation for the examination leading to Graduateship of the Royal Institute of Chemistry commences on September 22, 1958. The course (works based) is of four years' duration and involves six-months' study at College each year. The normal requirements for admission to the course will be successes at " A " Level (G.C.E.) or comparable examinations, in chemistry, physics and mathematics and three suitable ordinary level subjects.

Inquiries from industrial firms, research organizations, and government departments will be welcomed. Particulars from the Secretary, Chelsea College of Science and Technology, Manresa Road, S.W.3.

UNIVERSITY OF LONDON

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COURSE FOR M.SC. DEGREE IN RADIATION PHYSICS

An intercollegiate course for this degree will commence in October, 1958, in the above schools of the University.

The course, which extends over one or two academic years, will comprise lectures and practical work in nuclear physics and the properties, interactions and applications of ionizing radiations. It is designed as a part-time course involving attendance up to six hours per week for graduates working with radiations in medicine and industry, and a B.Sc. degree in physics is required for registration. Appropriate research facilities will be available for certain selected students.

The fee will be 10 guineas per academic term. Applications for registration should be made either to Professor J. Rotblat at St. Bartholomew's Hospital Medical College, Charterhouse Square, E.C.1, or Professor J. E. Roberts at Middlesex Hospital Medical School, Mortimer Street, W.1, from whom further particulars may be obtained.

UNIVERSITY OF BRISTOL

DIPLOMA IN HORTICULTURAL SCIENCE

DIPLOMA IN PLANT PATHOLOGY (including ENTOMOLOGY AND PROTECTION)

The above postgraduate Diploma courses will be available during the session 1958-9. Conducted in part at the Long Ashton Research Station, they are intended primarily for those with good honours degrees in science who seek careers in horticultural research, at home or overseas. The course in Plant Pathology and Protection permits specialization in any approved branch of the subject, including applied entomology. The Horticultural Science course commences on September 15, the Plant Pathology course on September 29. Both courses extend over a full session of three terms ending in June or July, and include some additional practical work during the vacations. Time is allowed during the summer term for some original investigation.

Early application for the remaining vacancies should be made to the Registrar, the University, Bristol 8, from whom full particulars and entry forms may be obtained.

UNIVERSITY OF MANCHESTER

The next session commences on Thursday, October 2, 1958.

OFFICIAL APPOINTMENTS

UNIVERSITY OF ALBERTA HOSPITAL

EDMONTON, ALBERTA, CANADA

Applications are invited for the position of Assistant Director of the Clinical Laboratory Services. The duties will be concerned with the future development of the biochemistry laboratory service in the hospital, consulting and advising on clinical problems and research projects involving biochemistry and teaching. A teaching appointment in the University of Alberta Medical School, while not automatic with this appointment, is customary. There will be ample opportunity to carry on individual research. The qualifications required are a degree in medicine and special training and experience in biochemistry. Preference will be given to those holding the M.R.C.P. or F.R.C.P. or a doctorate degree in biochemistry. Male, age 30 to 40 preferred but not essential. Salary $10,000 to $12,000 per annum.

Further details may be obtained from Professor E. J. King, Postgraduate Medical School, Ducane Road, W.12, London, England. Interested parties should apply to the Medical Superintendent, University of Alberta Hospital, giving full details and the names of two references.

ARCS, PLASMA, SOLID STATE PHYSICS

Posts in the above fields are available for young graduates in physics, or in electrical engineering with strong interest in physics, preferably with Ph.D. or equivalent experience.

(1) For research into the physics and applications of high power arcs and discharges. (Laboratory at Greenford, Middlesex.)

(2) For research into the mechanism of conduction through insulating material. (Laboratory at Leatherhead, Surrey.)

Salary up to £900 per annum at Ph.D. or equivalent level. Superannuation under F.S.S.U.

Apply, stating post in question, to the Secretary, Electrical Research Association, Cleeve Road, Leatherhead, Surrey.

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CHEMISTRY DEPARTMENT

Head of Department: E. G. Cowley, M.Sc., Ph.D.(London), F.R.I.C.

RESEARCH ASSISTANTSHIP IN CHEMISTRY

Applications invited for Research Assistantship in Chemistry value £300 per annum, with additional remuneration for demonstration work not exceeding six hours weekly. Applicants should possess the B.Sc. (Special Chemistry) Degree of the University of London. Appointment for one year, renewable for further period subject to satisfactory progress. Selected candidate required to work for higher degree on approved physicochemical project.

Forms of application, obtainable from the Registrar, Brighton Technical College, should be returned to him as soon as possible.

W. G. STONE,
Director of Education.

UNIVERSITY OF ABERDEEN

Applications are invited for two Assistants in Chemistry (one Inorganic and one Physical). Salary on scale £700 to £850. F.S.S.U. and child allowance.

Particulars from the Secretary, the University. Aberdeen, with whom applications (two copies) should be lodged by August 30, 1958.

ROTHAMSTED EXPERIMENTAL STATION

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Assistant Experimental Officer to carry out chemical analyses of soils and plants. Degree in chemistry or agricultural chemistry, or equivalent qualifications. Starting salary between £550 (age 23) and £645 (age 26 or over) on scale rising to £800. Superannuation scheme.

Apply to Secretary, giving names of two referees.

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APPOINTMENT OF CHEMICAL ENGINEER

Applications are invited for appointment to a position of Chemical Engineer with the Organization's Division of Industrial Chemistry located at Fishermen's Bend, Melbourne. The appointee will be responsible, under direction from the research staff, fpr the work of a small team engaged in process and equipment development within the Division's Chemical Engineering Section. This Section is undertaking research and development work covering a wide range of chemical engineering activities. Applicants should possess a university degree or a technical college diploma in science or technology, together with wide experience in chemical engineering techniques. Dependent upon qualifications and experience, commencing salary will be determined within the salary range of Experimental Officer, Grade III, £A.1,786 to £A.2,006 per annum. Salary for a female appointee would be £A.170 per annum less than the corresponding male rates. For an outstanding applicant, a higher classification and salary will be considered. The appointment will be conditional upon a satisfactory medical examination and the appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges. Fares to Australia, including those of wife and dependent family, will be provided by the Organization. Details may be discussed with the undersigned.

Applications, quoting Appointment No. 590/680, and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service, if any, together with the names of not more than four persons acquainted with th applicant's academic and professional status sho reach the undersigned, from whom further r ticulars may be obtained, by September 19, 19

E. J. DRAKE,
Chief Scientific Liaison Offic
Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2.

UNIVERSITY OF MELBOURNE

READERSHIP IN STATISTICS

The University of Melbourne proposes to make an appointment to a Readership in the Department of Statistics and invites inquiries from statisticians with suitable qualifications and experience who might desire to be considered for the post. The salary range is £A.2,560 to £A.2,800 with annual increments of £A.50, the commencing salary to depend on the experience of the appointee. Some Departmental consulting work, if undertaken by the appointee, may be remunerated from the appropriate fee payable to the University.

The position will be filled by invitation and it is desired to make the appointment as soon as possible. Details regarding the conditions of appointment may be obtained from the Professor of Statistics, University of Melbourne, Carlton, N.3, Victoria, Australia. It would expedite matters if, when writing, full particulars of career and of teaching and consulting experience were to be given, together with the names of two or three people who might subsequently be appealed to as referees.

F. H. JOHNSTON,
Registrar.

ROYAL NAVAL SCIENTIFIC SERVICE Requires Senior Scientific Officers and Scientific Officers for Establishments in London area, Baldock, Portsmouth, Portland, Poole, Greenock and Rosyth. Main requirements are about 25 vacancies for Physicists, Electronic Engineers and Mathematicians in areas specified. The following particular vacancies also exist: Mechanical Engineer for work on gas turbine problems in the London area. Mechanical Engineers for work on design and development of U/W devices in Portland area. Metallurgists for Rosyth and Poole. Chemists (Physical and Inorganic) for Poole area, Baldock and London. Candidates must normally be natural born British subjects of natural born British parents, with at least first- or second-class honours degrees or equivalent high professional attainments. Senior Scientific Officers must have had at least three years' postgraduate experience and be not less than 26 years of age. Salaries (men): Senior Scientific Officer, £1,190 to £1,410; Scientific Officer, £635 to £1,110 (London)—somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between the ages of 21 and 32 to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A98/8A.

TECHNICAL EDUCATION AND SOCIAL CHANGE

IN his Hinchley Memorial Lecture last autumn on "An Education for Our Times", Dr. R. P. Linstead argued that any good system of education would give a good product out of good material, against a good social background; and by a good system of education he meant one starting in breadth and proceeding in depth in the honest study of genuine academic subjects. Dr. Linstead pointed out that in any system of higher education there would be gaps and shortcomings in regions outside the specialist subjects, and these gaps would be most noticeable where the talent is thin or the cultural and social background insecure. This is, he observed, one aspect of the general problem of the incapacity of man to keep up with the growth of knowledge and to adapt himself to the complexity of the world.

The universities in Britain have been increasingly aware of the close relation between their work and the social and cultural background of their students. The widening strata of society from which their students are drawn involve changes in the assumptions in their teaching and in the demand made on some of their institutions, for example, the university library, just as social change may involve changes in the content and the extent of their faculties. Not the least merit of Dr. Linstead's lecture was the way in which he showed how easy it is, without foresight, for such changes or new demands to place impossible burdens upon the universities, and to involve expenditure out of all proportion to the return to the community.

If, however, the provision of a broad general education has forced increasing attention to the bearing of social change on education—at least so far as the universities are concerned—the relation between technical education and social change has received comparatively little attention. Dr. S. F. Cotgrove's recent study of that subject* is therefore to be warmly welcomed, in that it directs attention to factors of supreme importance in considering the provision of trained man-power. Moreover, this fresh approach is in itself suggestive of new ideas; and although in the main Dr. Cotgrove is essentially factual, here and there he hints quite plainly if less forcefully than Sir Hugh Beaver did recently, that in education, for all our protestations, there is in Great Britain neither a national policy nor the national organization to secure one.

To read the recent report of the Minister of Education on "Education in 1957"†, bearing in mind that Scotland is excluded and that the chapter on university awards is now limited to arts subjects, since the Department of Scientific and Industrial Research took over the responsibility for science awards, is to realize how fully justified are Sir Hugh's strictures and the quieter comments of Dr. Cotgrove. What stands out from all three documents is the importance of dealing with education as a whole, and the danger and waste of sectionalism, whether geographical, administrative or disciplinary. There is at present no official means of securing a comprehensive view of the whole field or, short of Cabinet level, for securing concerted action if needed.

Sir Hugh Beaver devoted almost half his lecture on "Science and the State", given before the Institution of Chemical Engineers, to the question of education, showing how the production of an adequate supply of scientists and technologists depends on an effective national policy for education. In the absence of such a policy and the means to concert and to execute one, our hope of increasing the supply of scientists and technologists depends upon the agreement of a large number of departments, authorities, schools, colleges and other bodies that such an increase is necessary (and Sir Hugh might have added that many such bodies are dominated by people with no first-hand appreciation of science or technology); the immediate provision of the finance; and an adequacy of teachers. Sir Hugh Beaver emphasized the critical importance of the supply of teachers, but also referred to the inadequate equipment for science teaching of many schools, and finally stressed that the Minister of Education has neither the responsibility for concerting a policy to produce the technologists and scientists required, nor the necessary scientific advice.

That may be true, but the value of the Ministry of Education's report should not be under-estimated. It shows, very clearly, trends of which due account has to be taken even when we seek elsewhere the means for concerted policy and action. More boys and girls are now staying at school beyond the age of fifteen, and they are staying longer. Moreover, a graph given in the report indicates that, in consequence of the rise in the birth-rate during the past few years, the Ministry of Education is now expecting in ten years time a peak in the school population almost as high as that expected for 1961. A situation originally expected to be temporary may thus prove much more nearly permanent and require more permanent measures of treatment.

On top of this, in spite of record progress in school building, including a number of projects specifically to provide additional science accommodation, and a slight improvement in the staffing position in the primary schools, the staffing position in the secondary schools continued to deteriorate. With increasing recruitment and a record number of teachers in the maintained schools, the effect was only marginal, and the situation remains particularly critical as regards teachers of mathematics and science. The number of such teachers increased, nearly 400 more students concentrated on these subjects in their final year in college, and more than twice as many trained teachers attended the special supplementary courses; but the result was merely to prevent any further deterioration in the relevant staffing standards. A recent debate in the House of Commons on the possible deferment from National Service of third-class honours graduates in mathematics in order to enable them to take up teaching posts merely stressed the shortage of such graduates and the keen competition between teaching and Service training rather than held out hope of any relief from this direction.

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* Technical Education and Social Change. By Dr. Stephen F. Cotgrove. (Studies in Society.) Pp. 220. (London: George Allen and Unwin, Ltd., 1958.) 25s. net.

† Education in 1957: Being the Report of the Ministry of Education and the Statistics of Public Education for England and Wales. Pp. v+198. (Cmnd. 454.) (London: H.M. Stationery Office, 1958.) 9s. net.

Dr. Cotgrove is concerned with technical education rather than with education as a whole; but his survey brings out the dependence of technical education upon what is done in the schools. He provides ample evidence in support of Mr. J. J. B. Dempster's contention, in writing on the secondary modern school in a symposium of articles on the "Educational Framework of an Industrial Society" in *Research*, that if industry is to have the skilled personnel it needs and the secondary schools are to come into their own, a great deal depends upon the skill with which appropriate stimuli are sought and applied, and upon the pattern within which teachers in the secondary modern schools are called upon to work. This point seems to elude Mr. John Wellens in commenting on the series of articles, although he recognizes that secondary modern schools should, and were intended to, provide for the special needs of their pupils and that the secondary technical schools cannot make their full contribution to the supply of technologists unless they receive their proper quota of good students. Moreover, emphasizing that the correct preparation for a study of advanced technology is a good grounding in science and mathematics, Mr. Wellens points out that it is the grammar and public schools that have offered the best preparation for the study of technology, and accordingly the more adequate the secondary technical school becomes in training potential technologists, the nearer it will approach the grammar school.

That of itself should suffice to give pause to some of the attacks on the grammar school which are being made in the name of political dogma, and there is more to that end in Dr. Cotgrove's study. Two of his most valuable chapters are those in which he examines the recruitment of students and in particular the influence of secondary education on the recruitment of students to the technical colleges. Earlier chapters trace the stagnation in technical education in Britain before the 1930's—and even down to 1945—to the indifference and even apathy of industry. During the war years and from 1945 onwards, the changing attitude of industry to research and the increasing application of science to production have resulted in an increased demand for scientific man-power, which has been accompanied by a substantial increase in the attendance of students, both full-time and part-time, at courses in science and technology at the technical colleges and universities. Then Dr. Cotgrove seeks to examine the mechanisms by which the needs of industry for scientists and technologists are translated into the decisions of students to attend the appropriate courses, and to analyse the factors determining the recruitment of students to the technical colleges.

Dr. Cotgrove's survey indicates that, although the main motive in attending technical colleges is the expectation of occupational reward, occupation is the main factor determining attendance. The failure to attract manual workers is attributed to the small rewards in manual occupations for qualifications achieved, and to the fact that most students attend classes to get on in their jobs rather than to change their occupations. Nevertheless, social factors such as social origins can reduce considerably the potential supply of students in science and technology, though among part-time students this appears indirectly in the influence of social origins on entry to occupations and the association between occupation and part-time attendance. The social factors appear most marked in Dr. Cotgrove's survey of the polytechnics; but they also appear in the recruitment to various courses within the technical colleges.

This influence of social class was emphasized three years ago in the report on early school-leaving, as was the wastage through the failure to complete courses for which students have entered. Dr. Cotgrove suggests that attendance might be increased and wastage reduced by greater encouragement and assistance from employers, especially in the form of giving time off for the older students. In this connexion it may be noted that the report of the Ministry of Education records increases of 9 per cent in the number of young employees who attended part-time day release courses in working hours and of 13 per cent in the number of students attending full-time (including sandwich) courses. Sandwich courses now number 203 compared with about 100 when the White Paper on technical education was issued.

Dr. Cotgrove also brings out a close association between secondary education and further education. The grammar school 'leaver' is orientated both towards the universities and towards university courses in the technical colleges, and recruitment to the technical colleges and to courses in science and technology appears to have been hindered by the persistence of the educational and social values of the nineteenth century mediated by the grammar schools. Like the Advisory Council for Scientific Policy in its report for 1951–52, Dr. Cotgrove comments that the study of arts has enjoyed a higher prestige than science, while the superior prestige of science compared with technology has decreased still further the attraction of technical college courses to the grammar school leaver. This is due in part to the pressure by parents for courses leading to 'black-coated occupations' in commerce, finance and the professions; and the recent decline in the proportion of students which the technical colleges draw from the grammar schools and the secondary modern schools has been accompanied by a decline in the proportion of university and other advanced work in the colleges.

Pursuing this inquiry further, Dr. Cotgrove points out that, while the technical colleges contribute substantially to the supply of graduates in science and technology, only to a slight extent have the technical colleges acted in the post-war years as an overflow for the universities; at the time of the inquiry in 1955, not more than 20 per cent of the students in the sample were attending a technical college because they had been unable to secure a place at a university. Most had not even applied for such a place. Nevertheless, about a third of the full-time and one-half of the part-time students taking a national certificate course covered by the survey seem to prefer a university degree on the grounds of its prestige and greater educational and occupational value.

Dr. Cotgrove emphasizes the need to interpret this evidence with caution; but he is manifestly right in suggesting both that further inquiry is needed to show how far the pursuit of existing paper qualifications is meeting the educational needs of industry, and that more attention should be paid to the intermediate and technician level, which tends to be dominated by the training required for professional qualifications. The conduct of examinations is only one of the functions of a professional body; and although it is one way in which a professional association may serve social needs, it is one in which self-interest may easily lead to distortion and a tendency to safeguard sectional and professional interests rather than to serve public needs. There can be no question as to the public spirit which animates the educational policy of some professional bodies, but Dr. Cotgrove's survey also suggests some doubts as to whether in establishing a National Council for Technological Awards and the Diploma in Technology regard was being had, not so much to the needs of the students or of industry as to the supposed interests of the technical colleges themselves. Dr. Cotgrove makes no such comment, but his factual survey of what passes for policy in technical education relates very clearly the major problems to the conflicts of interest involved, and shows the way in which the original and primary functions of the technical colleges have been overlooked.

Those functions of training craftsmen and technicians in the principles underlying their trade can be met appropriately within the framework of local government administration. It is when this work is combined with that of training technologists that the growth of advanced courses requires concentration in selected areas and the recruitment of students from a wider area, with consequent problems of finance and arrangements outside the local authority area. The questions of prestige and of autonomy which result are liable to be debated subjectively rather than objectively, and such controversies have hampered the development of the technical colleges.

The value of Dr. Cotgrove's book does not lie in any positive contribution to the resolution of such controversies, but rather in indicating the factors to which weight must be given if our efforts to expand the supply of scientists and technologists, technicians and craftsmen are to succeed. Most technical colleges will continue their established role of concentrating on the training of technicians and craftsmen, though perhaps less exclusively on a part-time basis than Dr. Cotgrove implies; but the extent to which others concentrate on the training of technologists should be determined by considerations of man-power needs and resources rather than local or sectional prejudices or ambitions.

Further, more attention should be given to the influence of the social structure and to the educational system of Britain as a whole. Perhaps the outstanding lesson of the survey is that the system of further education must be conceived in relation to the structure of society if the demands for trained man-power are to be met. This involves some radical re-thinking of the relations between the various forms of secondary and further education, and equally a readiness to consider the impact of change on the various elements in the educational system. The apprenticeship system is scarcely mentioned in this study, but obviously has an important bearing, quantitative and qualitative, on the development of technical education. It is not the only point at which entrenched interests and the dead hand of tradition hinder adjustment of the educational system to changing needs of society.

If technical education is to meet the needs of Britain for trained man-power, there is no place for preconceived ideas. Dr. Cotgrove leaves no loophole for believing that any substantial increase in the output from the technical colleges is likely unless positive steps are taken to decrease the factors hindering recruitment. The White Paper on technical education proposed no such changes, and accordingly Dr. Cotgrove believes that any expansion is likely to result from the slow evolution of the system and the increase in the size of the age-groups from which students will be recruited during the next decade. Nor does he believe that the currently expressed needs of industry should dominate the nature of any educational re-organization. This, he urges, and rightly, should depend on much more detailed knowledge of the structure and functioning of the educational system and of the social forces which shape it. There is sound reason, while such knowledge is being sought, for avoiding fundamental change, and care should be taken to create no fresh obstacles to whatever changes or developments may appear necessary.

Such knowledge, however, and especially of the social consequences which are likely to result from educational policy, for example, the effect on social and industrial mobility, should be sought as a matter of urgency. When it is available, however, imaginative and constructive thinking will be no less imperative. To translate the results of such thought and knowledge into action will be a task demanding the co-operation of all concerned to see Britain take her full place in this age of technology; nor is it too early for professional associations as well as educational institutions to seek to promote such co-operation and to remove the misunderstandings and prejudices which are probably the greatest hazards to the formulation and execution of an adequate and effective policy of technical and technological education.

MOLLUSCAN DEVELOPMENT

Morphogenesis

The Analysis of Molluscan Development. By Prof. Chr. P. Raven. (International Series of Monographs on Pure and Applied Biology. Zoology Division, Vol. 2.) Pp. xii+311+12 plates. (London and New York: Pergamon Press, 1958.) 70*s*. net.

MODERN developments in experimental embryology may, as Prof. C. P. Raven notes in his introduction to this book, be reviewed in one of two ways. Certain problems may be concentrated on while drawing examples widely from the animal kingdom, or attention may be restricted to a single group, so permitting a survey of the normal course of development as the logical background to the causal analysis which is the aim of experimental studies. Prof. Raven has here chosen the latter course, dealing, as he is so highly qualified to do, with the Mollusca.

Indeed, this phylum offers an almost embarrassing wealth of material for description and analysis. Of its numerous marine representatives, some have larval development, but this may be abbreviated in many ways leading to direct development and even, in the Cephalopoda, to meroblastic discoidal cleavage. The freshwater Gastropoda and Lamellibranchia and the terrestrial Gastropoda exhibit other patterns of development including parasitic glochidia larvæ, ovo-viviparity and special adaptations in connexion with land life. They also present advantages to the investigator which Prof. Raven has fully utilized in his numerous studies on *Limnaea stagnalis*.

The book starts with an account of oogenesis, particularly valuable for its account of cytochemistry, followed by chapters on maturation and fertilization and on cleavage. Descriptive sections, dealing with structure in all its aspects, are followed by accounts, inevitably shorter, of work on causal analysis. The 'outfit' of the embryo is shown to consist of (1) its genotypical constitution, (2) an assortment of substances in the egg cytoplasm, and (3) a cortical field. The latter is considered not only to have a polar structure but also to be organized in dorsoventral and transverse directions.

The same course is followed in dealing with gastrulation and with embryogenesis, with the important distinction made between 'chemo-differentiation' in the embryo and the later 'chemical differentiation' which accompanies histological differentiation. The two, as the author emphasizes, represent opposite trends, one "functioning elements containing a great amount of fuel" and the other "formative cells, in which anabolism preponderates, leading to a synthesis of living protoplasm. . . ." It is interesting to note how, in the course of modern experimental attack, the old idea of mosaic development in the molluscan egg has been destroyed.

Criticisms are relatively minor. Some order might have been imposed on nomenclature when dealing with the excretory organs: larval kidneys include protonephridia, and these, on the evidence of different authors, are said to arise from either ectoderm or mesoderm. No reference is made to the work of Goodrich. The chapter on organogenesis is not altogether satisfactory. There are too few figures, making the unaided verbal descriptions most difficult to follow, for example, in the account of gill formation. There is also some apparent lack of knowledge of adult structure. "Inner and outer gill", meaning the inner and outer demibranchs of the bivalve ctenidium, is not satisfactory; supporting rods are always present within ctenidial filaments; the shell of a bivalve is a single structure with the ligament formed in the same manner as the valves. It does not appear to be realized that there is a fundamental difference between the asymmetry of the kidneys in the Archæogastropoda and in the remaining Gastropoda. There are also other matters which might suitably have been checked by a malacologist.

But it would not do to end on a note of criticism when dealing with a book for which many, including this reviewer, will long be grateful. Not only does it provide an admirable summary of the present state of knowledge in a difficult but most active field of research; it should be the means of stimulating further research. C. M. YONGE

HORMONES

Biochemical Contributions to Endocrinology

Experiments in Hormonal Research. By Sir Charles Dodds. (Stanford Studies in the Medical Sciences, No. 8. The Lane Medical Lectures, 1956.) Pp. viii+76. (Stanford, Calif.: Stanford University Press; London: Oxford University Press, 1957.) 18*s*. net.

IN this volume, which is based upon five Lane Medical Lectures delivered at Stanford University in 1956, Sir Charles Dodds recounts some of the biochemical research work in relation to endocrinology at the Courtauld Institute, Middlesex Hospital. Following a description of early work on insulin and posterior pituitary lobe factors, which is now only of historical interest, the author gives a fascinating account of the difficulties and uncertainties which beset his colleagues and himself in their search for synthetic compounds with œstrogenic activity. Isolation from urine of five different compounds with œstrogenic properties indicated clearly that, in this field at least, the contemporary belief that hormone specificity and structure were closely related was untenable. Such was the simple starting point of this inquiry, and rarely has persistent effort yielded such abundant reward. In stilbœstrol, hexœstrol and dienœstrol the target of cheap, highly active, oral, synthetic œstrogens was achieved, but perhaps the most significant outcome of this work has been the subsequent application of these powerful drugs. Apart from their use in menstrual disorders and weaning, Huggins was able to show that they had useful and possibly unique application in the treatment of carcinoma of the prostate and breast.

The use of synthetic œstrogens in cicuration to improve the quality of chicken and heifer meat has already great economic importance, but is not without potential danger to the animals, to those who handle the treated fodder and to the consumer of the meat. In the future, these compounds, or their derivatives, may find useful application in the control of lipid metabolism in atherosclerosis and allied conditions. It is well known that arterial degeneration is rare in women during active sex life and that the incidence of cardio-vascular disease in men and post-menopausal women with an associated disturbance of lipid metabolism is much higher. There is already some evidence that the abnormal plasma lipid pattern can be successfully treated by œstrogen therapy.

In bringing the brief story of the Courtauld Institute up to date, Sir Charles gives a concise account of the historical background which led to the discovery of aldosterone by Dr. Tait and his wife. Although at some pains to point out the advantages which may follow the association of workers of different disciplines, the author does not comment on the uniqueness of this combination of a radiation physicist and a biologist which resolved the difficulties of the amorphous fraction which had defeated chemists for a quarter of a century. The establishment of the constitution of aldosterone and its subsequent synthesis may have solved the chemical problems, but the important questions of physiological function and clinical use remain unanswered. That aldosterone influences the electrolyte balance is beyond doubt, but whether it does so primarily by action on sodium, potassium and chloride ion excretion in the renal tubules or indirectly by controlling the extra-cellular fluid volume by modification of the permeability of cell membranes is uncertain. Unlike other steroids synthesized in the adrenal cortex, the secretion of aldosterone does not seem to be under pituitary control. A. E. Kellie

FOSSIL VERTEBRATES

Studies on Fossil Vertebrates

Essays presented to David Meredith Seares Watson. Edited by Prof. T. Stanley Westoll. Pp. xii+263. (London: The Athlone Press, University of London, 1958.) Distributed by Constable and Co., Ltd., London. 35*s*. net.

This collection of essays deals with a variety of problems of prime interest to vertebrate palæontologists, some relating to the evolutionary history and comparative anatomy of extinct animals, others to the environmental conditions in which these animals lived, and the evidence offered in this respect by the fossiliferous rocks. In all these fields Prof. D. M. S. Watson has made lasting contributions, and it is highly proper, therefore, that the volume now published in his honour, should have this broad coverage.

Among the articles dealing with modern aspects of evolutionary theory, those entitled "Prophetic Fossils" and "Time and Evolution" are worthy of special mention. In the first, Sir Gavin de Beer and W. E. Swinton state the case, with many examples, of paedomorphosis versus recapitulation in the evolution of animals. In the second, J. Brough makes some critical and, as it seems, well-founded comments on the dynamics of evolution as interpreted by the neo-Darwinian school. Taking as an example the history of Actinopterygian fishes during Permo-Triassic times, Brough emphasizes that the transition from the Palæoniscoid to the Sub-Holostean, and afterwards the Holostean stage, which quite obviously took place independently within several different lines, can scarcely be attributed to conditions of small populations in connexion with environmental instability. In this case, as also with regard to the phyletic development of the jaw-apparatus in various mammal-like reptiles, the explanation rather seems to be that the evolution was non-adaptive, that it was influenced above all by variations in the mutation-rate, and that the mutations were, at times, not wholly random, but in some way directional. In such large-scale evolutionary outbursts where new orders, classes or phyla emerged, the causative factor was, so Brough maintains, probably an extremely high mutation-rate. Natural selection, on the other hand, may, in Brough's opinion, have been active as a guiding force in evolution, but only on a lower taxonomical level, for example, for the rise of new species, genera and to a large extent even families. Reviewing the phyletic history of animals from the early Cambrian onwards, Brough, in conclusion, tends to regard evolution as a decelerating process, in which large-scale surges all belong to the past, and which goes on at an ever-decreasing speed until, at some future date, it may cease altogether.

Three other articles in the volume have been written with the intention of summarizing and critically analysing the occurrences of fossil vertebrates in certain geological time-intervals or in certain specific areas. Valuable contributions of this kind are given by two American palæontologists: E. H. Colbert, who, in "The Beginning of the Age of Dinosaurs", presents a broad outline of the evolution of amphibians and reptiles during the critical Triassic period, and A. S. Romer, who, in a highly competent manner, deals with the Texas Permian Redbeds and their vertebrate fauna. E. S. Hills has contributed a brief review of Australian fossil vertebrates which, in condensed form, yields much up-to-date information on the rich finds, in that part of the world, of fishes and tetrapods in strata ranging from the Middle Devonian to the Late Tertiary.

The habitat of fossil lower vertebrates is the subject of two articles, "The Geological Environment of Fossil Fishes", by D. H. Rayner, and "Original Environment of the Craniates", by E. I. White. Miss Rayner has set herself the task of briefly evaluating to what extent such evidence as state of preservation, lithology of enclosing rocks, etc., may reflect the original environment of fossil fishes, giving, in this connexion, a rather detailed account of various fish-faunas from the British Jurassic. E. I. White, on the other hand, has chosen the more limited but highly controversial problem of fresh versus salt water as the habitat of the early vertebrates. After a careful consideration of the evidence, zoological and geological, White concludes that the earliest Craniates were wholly marine, and that the Ostracoderms lived off shore or in estuaries during pre-Devonian times. White successfully disposes of some of the irrelevant or untenable argumentation by which this problem has often been obscured. The frequently cited circumstance, for example, that in the early Devonian the Ostracoderms and fishes occur predominantly in continental sandstones, clearly proves nothing at all concerning the original habitat of the earliest vertebrates; and the view that the Ordovician and Silurian vertebrates belonged to inland waters, and that their detached exoskeletal plates and scales were washed out after death into the sea by rivers, is entirely unsupported by the facts as we know them. There may still be some diversity of opinion on certain of the aspects of early vertebrate history touched upon by White (for example, the successive phases in the phyletic development of the exoskeleton), but this by no means lessens the validity of his conclusions referred to above.

Finally, three articles deal with problems of palæoichthyology. F. R. Parrington and A. Heintz both discuss the anatomy and mode of life of the Anaspids, and in "The Lateral Fin-fold Theory and the Pectoral Fins of Ostracoderms and Early Fishes" T. S. Westoll, the editor of the volume, pursues an important problem of comparative anatomy. Interesting in many ways as they certainly are for specialists, none of these articles can be reviewed in detail here. It may be mentioned, however, that whereas Heintz in his description of *Birkenia* rejects the view that the Anaspids have a suctorial mouth, Parrington, who mostly considers *Lasanius*, strongly favours the opposite view. According to the latter, the Anaspids may, in their mode of feeding, have been intermediary to some extent between the Cephalaspids on one hand, and the modern lampreys on the other.

The volume of essays presented to Prof. Watson makes excellent and stimulating reading throughout. Its highly varied contents, to which no full justice can be done in a short review, should be of considerable interest to anyone working with vertebrate phylogeny. TOR ØRVIG

BIOLOGICAL TESTING OF INSECTICIDES IN THE LABORATORY

A Critical Review of the Techniques for Testing Insecticides

By Dr. J. R. Busvine. Pp. ix+208. (London: Commonwealth Institute of Entomology, 1957.) 30*s*.

IN the past ten or so years a number of rather similar books have appeared, each of them about the properties, uses and modes of action of insecticides. Dr. Busvine's book is the first to be entirely devoted to methods of testing insecticides; he is to be respected for his courage in tackling a subject with so many specialized subdivisions.

The book does not deal with methods for field tests, nor with chemical tests, but covers all types of laboratory biological tests. It is a review of a large subject, not just a collection of descriptions; it does not list all the methods that have been used for each type of test; and it does not give full details of more than a few. Dr. Busvine has concentrated rather on the principles and theories involved in tests, and on giving suitable guidance.

One of the praiseworthy aims of the book is to encourage greater simplicity and standardization of method. The subject is now well past its pioneering stage, and the methods used have been increasing in diversity and number. As the author says, research workers are "doggedly individualistic"; this has often made it difficult or even impossible to make comparisons among results obtained in different laboratories. There are enough uncontrollable sources of variation in any one type of test without individual workers adding variants of their own.

After three general chapters on principles, and on handling and standardization of insects, the author deals with each type of test, chapter by chapter.

However, there are quite a number of errors in detail, which give the impression that the book has been hurriedly prepared. In matters of theory and of interpretation of results, there are some more serious errors. These may not concern the routine tester, but may mislead research workers. For example, Dr. Busvine uses Ferguson's principle to explain the positive temperature coefficient of toxicity of hydrogen cyanide and the negative coefficient of toxicity of DDT. Ferguson specifically excluded hydrogen cyanide; and his principle can never offer more than a partial explanation for the temperature coefficient of DDT, which may sometimes, in fact, be positive.

There are some omissions. In the sections about humidity, there is no mention of saturation deficiency—a method for expressing humidity measurements with which many biologists are unfamiliar, and which could well be brought into a book like this. There is no general section about the various objective methods for telling whether or not an insect is affected by poison, or for assessing effectiveness in other ways; on the other hand, this question is quite fully dealt with in the section on tests with mosquito larvæ. This emphasis on tests with insects of medical importance is indeed a characteristic of the whole book.

The final chapter is about "Toxicological Statistics", or methods for planning tests and for assessing their results. It is refreshing to note that Dr. Busvine calls for moderate use of statistics when results are prepared for publication.

The lay-out of the book does not make for the greatest efficiency in use. There is no index. Instead, there is a systematically arranged table of contents, which is a list of some of the many headings that occur in the text. The material is classified and subclassified so much that there are ten different types of heading; as many as five of these may occur on one page, some of them often more than once. Many readers will find this irritating. In addition, some topics may be hard to find, because the material is not always logically set out. Thus, under "General Principles of Insecticide Testing" we find, besides some experimental detail, an account of the various aims that experimenters may have in mind when planning their tests; general principles are found under "Toxicological Statistics". The effects of temperature and humidity after treatment are described under "Standardisation of Insects for Testing". Probits are mentioned casually from place to place in the body of the book, but are not defined until well into the last chapter.

This book is not perfect, but it should be useful all the same, especially as it is the first of its kind. There are more than 550 references, covering all the important branches of the subject. A. H. MCINTOSH

GENERAL ENTOMOLOGY

A General Textbook of Entomology

Including the Anatomy, Physiology, Development and Classification of Insects. By A. D. Imms. Ninth edition, entirely revised by Prof. O. W. Richards and R. G. Davies. Pp. x+886. (London: Methuen and Co., Ltd., 1957.) 75*s*. net.

WHEN in 1925 A. D. Imms published his "General Textbook of Entomology" it at once became clear that here was a synthesis of a major field of zoology which was likely to prove to be an outstanding work in its sphere for at least half a century. The third revised enlarged edition of 1934 served to maintain the value and prestige of the work, but the subsequent so-called editions, from the fourth (1938) to the eighth (1951), were mere reprints and the book has thus been falling far behind as the already great development of the subject increased in momentum over the years. The publication, therefore, of a ninth edition is of great value, and it can be said that the authors have done a difficult job outstandingly well. It is scarcely possible, even if it were desirable, to attempt a minute critique of a work containing such an immense amount of detail; for the great merit of Imms's text-book was the masterly way in which he condensed an enormous amount of information into a relatively short space (750 pages) with a wonderful flair for retaining what is really important.

In the new edition the original format and layout have been retained and we are obviously dealing with 'the same book'. But it has been enlarged by nearly 200 pages, on almost every one of which there seems to be some significant change. As the editors point out, about 4,000 papers and books on insects now appear annually, and such an output from the production line does indeed set an almost impossible task to would-be summarizers. Obviously much must be left out. The editors have made their selection with sound judgment. They could, of course, have cut out the physiological side entirely and thus greatly eased their task. It would, I think, have been a great pity to have done this, and although the physiological chapters cannot be, from the nature of the case, as full and thorough as the rest, to have left them out would have so changed the nature of the book as to deprive it of one, at least, of its great merits. Quite apart from the great and steady increase in the quantity of publications on the insects, the task involved as a result of the mere increase in the number of described species is almost overwhelming. Perhaps we get the best idea of this increase if we compare two of the main groups. In 1925 the text-book writer was concerned with 50,000 species of Diptera, comprising 45 families. He now has to deal with 64,000 species classified into 83 families. In the Hymenoptera the classification has not been extended very much although the described species have risen from 60,000 to 100,000. All this has, of course, to be expressed in the general classification.

The original "Imms" classified the Insecta into 23 orders, grouped in two sub-classes. R. Jeannel in Grassé's recent text-book adopts a modified Martynov classification of 40 recent orders comprised in two sub-classes and 15 super orders. Brues and Melander (1932) had 34 orders against Imms's original 25. Prof. Richards, in the new edition of "Imms", has been very conservative in this. He considers that while many of the new divisions adopted by Handlirsch (1908), Martynov (1938) and others are probably justified and certainly desirable in attempting to incorporate the much greater knowledge of fossil insects that we now have, many of the innovations are of doubtful success; so although a number of the changes are, in principle, approved and receive critical discussion, the layout of the scheme of classification has not been very greatly changed. The general student is at least spared the task of having to remember 35 or so recent orders, being let off with 29.

Among the sections in the latest edition which can be regarded as mainly new are the general ones on classification, sections of those on the musculature, physiology of the nervous system, sense organs and perception and on digestion. The section on the physiology of respiration does not seem to have quite kept pace with some of the rest; and neither the account of the air sacs nor that of the mode of action of the closed tracheal system is quite as clear and precise as would now be possible and as might have been expected. However, there is a good new account of the blood and blood system and an excellent short summary of the present state of knowledge on endocrines.

Perhaps the most important new feature of the book is the large number of new and important keys which it provides. Almost all the main orders have received some new treatment in this respect and particularly outstanding are the new keys to the Diptera, the Hymenoptera and the Coleoptera, the last being largely based on the work of Crowson. There is no doubt at all that the keys to these three main orders have been enormously improved. The increase in the number of illustrations has not kept pace with that of the text; in fact the new edition has somewhat fewer than the old. This is, perhaps, rather a pity and it would seem that more of the old figures might have been discarded for new ones. Where changes have been made, however, they seem to be excellent and in particular some of the new illustrations of the external morphology of the Hymenoptera will be very useful. Considering the book as a whole there is no doubt that it is an eminently worthy revision of a really outstanding text-book, and not much higher praise than that can be given. It should, with enough subsequent less intensive revisions, enable the work to retain its place in the forefront for many years.

W. H. THORPE

EASTER ISLAND CULTURE

Aku-Aku

The Secret of Easter Island. By Thor Heyerdahl. Pp. 368+37 plates. (London: George Allen and Unwin, Ltd., 1958.) 21*s*. net.

EIGHT years after Thor Heyerdahl made his epic voyage on the *Kon Tiki* raft, he returned to Polynesia with an archæological expedition to undertake a study of Easter Island culture. The initial results are given in this vividly written and finely illustrated book. As well as accumulating a great deal of general information about Easter Island culture, the expedition performed two very important services. Some of its members engaged in much more extensive scientific excavation than any earlier visitors had done, while Heyerdahl himself discovered a series of family caves with curiously carved stone figures of novel type.

The book sets out to show that the secret of Easter Island, including the 'mystery' of how its giant statues came to be, has now been solved. But the anthropological reader may well feel that the author, in solving some problems, has only created some new ones. It is good to have the actual proof by word and photograph of how these enormous statues can have been hauled along the ground by ropes and raised by wooden levers on stone ramps to their upright position. But this is confirmation rather than discovery of method. Métraux, in 1934, was told of the embankments and ramps by means of which the statues were brought to the level of the platform on which they would be placed, and also of wooden levers, crushed potatoes and round stones which helped these heavy masses to slide along. Even in 1914 Mrs. Routledge had found behind some statues the mounds of stones which had supported them while they were being raised into a vertical position. But Heyerdahl's organizing gift of enlisting enthusiastic co-operation has now given us a practical demonstration.

The weights involved still remain somewhat obscure. Heyerdahl speaks of 180 people pulling a statue of 12 tons and of twelve men raising a statue weighing between 25 and 30 tons. He also talks of one, of which the density and measurements were obtained, weighing 50 tons. Métraux, taking the density of the volcanic tufa as 2.48, as measured in the Laboratory of Geology, Paris, calculated that statues of this material which were actually transported weighed only 5–6 tons, although others still at the site of manufacture were as much as five times that weight. Heyerdahl is critical of the estimates of his predecessors and speaks of the rock as very hard ("hard as bone inside the outer surface"), but gives us no precise data from which comparative estimates can be checked.

The stone figures from the caves raise questions only meticulous study can answer. By a combination of friendliness, gifts, ingenious bluff and playing on the Easter Islanders' notions of spirits, Heyerdahl obtained access to a number of caves, the secret of which appears to have been most carefully guarded from previous investigators. He is to be congratulated on a magnificent feat of persistent inquiry and discovery. But the results of this exciting story as yet are still rather puzzling. These extraordinary figures, which all seem quite small, include bearded heads, stone skulls, a three-masted 'reed boat', a whale with a house on its back, a woman with a fish roped to her shoulders. Who made them ? From the photographs and description some appear to be ancient specimens. Others look like relatively modern work. Heyerdahl himself says that some stone figures were ancient, that some were made by the father and the grandfather of the woman from whom he received them, that some other figures, allegedly from the caves, were made as fakes to sell to him and treated to look old, and that the 'mayor' of the island, a superb carver, rigged up a complete cave of bogus figures in an attempt to hoax him. Out of this medley, selection of the genuine traditional specimens cannot have been simple. Moreover, we are still almost without a clue as to their meaning.

The book concludes with a restatement of the author's contentions as to the American origin of Polynesian culture—arguments based so far on very debatable evidence. We therefore await with interest the detailed analysis of the expedition's archæological findings. RAYMOND FIRTH

THE YEASTS

The Chemistry and Biology of Yeasts

Edited by A. H. Cook. Pp. xii+763. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 22 dollars.

YEASTS have been studied for many years because of their importance in fermentation industries, and this has led to the building up of a large amount of miscellaneous information, most of it directly related to industrial practice, but including also many studies of more general application. More recently, interest in yeasts has intensified and much work of a fundamental nature has been done on the biology and biochemistry of these organisms. The time is therefore opportune for an authoritative and comprehensive survey of what is known about yeasts. The book under review has this as its aim and it hits the target very near the bull's eye. Perhaps the best idea of the scope and standard of the work may be conveyed by a list of the subjects treated, with their authors' names: yeast classification (J. Lodder, W. Ch. Slooff and N. J. W. Kreger-van-Rij), ecology (A. Lund), life-history and cytology (Ö. Winge and C. Roberts), genetics (Ö. Winge and C. Roberts), chemical composition (A. A. Eddy), growth (E. O. Morris), fermentation and respiration (F. F. Nord and S. Weiss), synthesis and degradation of cellular carbohydrates (W. E. Trevelyan), nitrogen metabolism (G. Harris), technology (Magnus Pyke), pathogenicity (G. C. Ainsworth), food spoilage activities (M. Ingram), and flocculation (H. E. Jansen). The success or failure of a collection of individual articles such as this, however, depends not only on the contributors, but also to a large extent on the editor. In this case, the editor, A. H. Cook, has obtained admirable results; his team of authors is well balanced and includes some with a world-wide reputation; these authors have obviously been well coached so that there is a reasonable uniformity of style; their areas of activity have been adequately defined so that while the field is well covered there is little unnecessary overlapping, and their articles all come up to a very high standard of freedom from linguistic errors and misprints.

It is not possible to comment on each article individually within the space of a short review, but in many ways they are remarkably similar. Each article surveys the present state of knowledge in a particular field, with special attention to work published within the past few years; it is subdivided under headings, sub-headings, and in some cases sub-sub-headings; it is well illustrated with figures and tables and is followed by an alphabetical list of references, which in every case includes literature up to 1956 or 1957. There are some outstanding articles by authors who, while contributing largely to the field they review, have been able to give an objective view of the subject as a whole; these are authoritative and critical surveys of great value. Other articles do not quite come up to this high standard. The articles are followed by an author index (containing about 2,500 names) and a subject index (69 pages). Altogether, the book is by far the best available statement of our present knowledge of yeasts.

I should have liked fuller discussion of adaptation, autolysis, sulphur metabolism, the Pasteur effect and of the formation of esters and other secondary products of fermentation, but there would be difficulty in deciding what to leave out in order to make space for this new material. In the author index I found almost every name which came to mind, but in the subject-index under the letter 'A' I failed to find acetal, acetyl methyl carbinol, actidione, adaptation, adaptive enzymes, aeration, amyl alcohol or azide; no mention of the first three of these was found in the text, but the remainder are mentioned in the text and some are indexed under other headings (enzymes adaptive, *iso*-amyl alcohol and sodium azide); this indicates that the cross-referencing might be improved. Other changes that could be recommended are that footnotes should be eliminated, and that the magnification should be indicated on the photomicrographs where it is missing. One other criticism which might be made is that the price is high; but the paper, printing and binding of the book are of the highest quality and, if this is the cost of producing such a book, then we must pay it, because we would not wish for any lowering of the standard of production and because access to this book is a necessity for everyone who is working with yeasts. R. B. GILLILAND

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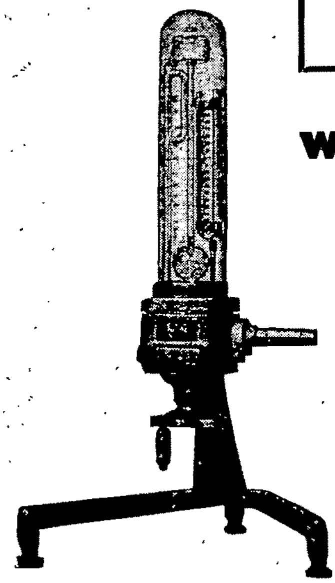

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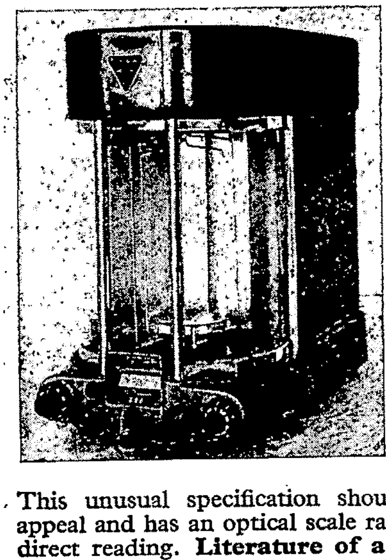

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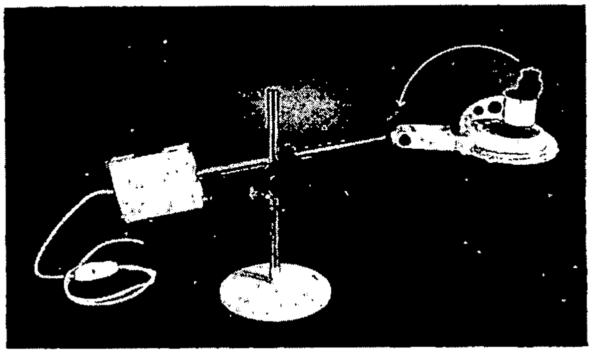

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Annual Review of Nuclear Science

Vol. 7. Edited by James G. Beckerley, in association with Robert Hofstadter and Leonard I. Schiff. Pp. viii+496. (Palo Alto, Calif.: Annual Reviews, Inc., 1957. Published in co-operation with the National Research Council of the National Academy of Sciences.) 7 dollars.

VOLUME 7 of the "Annual Reviews of Nuclear Science" contains the following twelve contributions: Mu-Meson Physics, J. Rainwater; Radiochemical Separations by Ion Exchange, K. A. Kraus and F. Nelson; Equipment for High Level Radiochemical Processes, N. B. Garden and E. Nielsen; Cellular Radiobiology, E. L. Powers; Biochemical Effects of Ionizing Radiation, B. E. Holmes; Vertebrate Radiobiology (Lethal Actions and Associated Effects), V. P. Bond and J. S. Robertson; Vertebrate Radiobiology (The Pathology of Radiation Exposure), C. C. Lushbaugh; The Collective Model of Nuclei, F. Villars; Nuclear and Nucleon Scattering of High-Energy Electrons, R. Hofstadter; Collision of $\lesssim 1$ BeV. Particles (excluding Electrons and Photons) with Nuclei, S. J. Lindenbaum; The Measurement of the Nuclear Spins and Static Moments of Radioactive Isotopes, W. A. Nierenberg; Hyperons and Heavy Mesons (Systematics and Decay), M. Gell-Mann and A. H. Rosenfeld.

The articles in this volume are up to the very high standard which we have come to expect in this series. Most of them represent excellent up-to-date surveys which, in different ways, should be equally valuable to the expert or the new research student who wants a readable introduction to a new field and is overwhelmed by the published literature. The review by Rainwater and, to a much lesser extent, that by Gell-Mann and Rosenfeld were written at an inopportune time. They were concluded within a few months of the discovery of parity violation in weak interactions, when these subjects were in a state of violent change. As a result, much experimental work done since their completion is missing from these surveys and theoretical conjectures based on conflicting or sparse data would be on sounder foundation to-day.

It would seem most desirable to be able to buy individual articles (friends of authors may already be lucky enough to receive such complimentary copies) at a small fraction of the present price.

F. MANDL

Nuclear Chemical Engineering

By Prof. Manson Benedict and Prof. Thomas H. Pigford. (McGraw-Hill Series in Nuclear Engineering.) Pp. xiv+594. (London: McGraw-Hill Publishing Company, Ltd., 1957.) 71*s*. 6*d*.

A WIDE interpretation of the title is possible, but the authors have made it clear that they are concerned with the materials of importance in nuclear reactors and the novel processes which have been developed to concentrate, purify, and separate them. The use of nuclear radiations in processing materials is not dealt with.

The strength of the book lies in its very thorough theoretical treatment of the various flow sheets which have either been developed or grown in importance as a result of the growth of nuclear power. On this subject the reader will expect much from two such distinguished authors, and he will not be disappointed.

The thermal nuclear reactor is treated simply as a chemical engineering process and, rightly, no attempt has been made to summarize the theory of nuclear reactors. Fuel flow sheets are developed for a typical reactor. Although the principles are well presented, a more critical review of the effects of the assumptions on the results would be welcomed.

Two chapters deal with the production and properties of uranium, zirconium, thorium and beryllium, but no mention is made of graphite. There is an excellent description of solvent extraction processes.

The chemical and radioactive properties of irradiated fuel receive adequate treatment, as does the separation of reactor products. A very thorough and well-written account of the theory of isotope separation and applications is given.

The production is good except for the poor photographs. The authors' wide experience of industry and university has resulted in the production of a first-class book which is highly recommended.

W. MURGATROYD

Progress in Biophysics and Biophysical Chemistry

Vol. 8. Edited by Prof. J. A. V. Butler and Prof. B. Katz. (Progress Series.) Pp. viii+409. (London and New York: Pergamon Press, 1957.) 105*s*. net.

THIS volume has four articles on various aspects of protein synthesis and the nucleic acids, and five others on hearing, colour vision, bacterial electrochemistry, the nerve axon and red cell permeability. No doubt they will all be of value, and some will certainly be of great value, to specialists in these fields. But it is not to this clientele that the editors say they address themselves. They aim higher and "believe that collections of critical reviews of this kind will help to provide a meeting ground for all those scientists who, in spite of their very different methods of approach, are concerned with the applications of physical principles to biology".

In judging their success it must not be forgotten that the scientific reader out to widen his acquaintance is an extremely shy person. In a good deal of the book, unfortunately, the approach is not likely to charm his hesitancy. We can scarcely blame the editors for this, for it is notoriously difficult to extract from the expert a critical account of the fundamental facts and ideas current in his subject, and to get it written in sufficiently attractive and explicit language to be interesting and intelligible to his scientific neighbours. Rather we must be grateful to them, and count their book a success, for the two or three outstanding articles it contains which do possess the rare qualities needed to make friends and influence people.

P. A. MERTON

An Introduction to Probability Theory and Its Applications

Vol. 1. By Prof. William Feller. Second edition. (Wiley Publications in Statistics.) Pp. xv+461. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 86*s*. net.

THIS, the second edition of Prof. Feller's well-known book, contains a new chapter on "Fluctuations in Coin Tossing and Random Walks", and in it results obtained earlier by advanced methods are now deduced by elementary means. Throughout the book there is increased emphasis on waiting times.

There is a rather remarkable aspect of duality pervading the account. The theory of probability is developed with a degree of rigour which should satisfy the pure mathematician. But there are also applications to practical situations, including the estimation of the size of an animal population, the distribution of misprints in a book, or of raisins in a cake, or of flaws in a material; and the exposition is made the more colourful by reference to card games, birthdays and the spread of rumours.

The later chapters include one on random walk and ruin, and several covering Markov chains, recurrent events and time-dependent stochastic processes. These topics, apart from their current interest to research workers, have important applications in the study of industrial operations, and an example of the latter is the subject of machine interference, an aspect of which is treated on pp. 416–422.

The book is very well produced and only one error has been noticed. On p. 164, x^2 not x should appear in the definition of $\varphi(x)$; the same mistake occurs on p. 166. The title page still describes the work as Volume 1. But it is generally known that Volume 2 has not appeared, and it is believed that it will not appear. On the other hand, on p. 173 it is still stated that a certain matter "must be postponed to the second Volume". Thus, an enigma still surrounds the present work, and it would be good if the publishers could clarify the position.

L. S. GODDARD

The Birds of the British Isles

By Dr. David Armitage Bannerman. Vol. 7: Anatidae (Conclusion). Pp. x+256+27 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1958.) 63*s*. net.

DR. BANNERMAN'S seventh volume covers the dabbling and diving ducks, including the sawbills. He has been able to draw upon even richer material than usual, as the ducks have always been special favourites of some ornithological writers, such as J. G. Millais; they are also well known to sportsmen, who have added to the store of information—especially about habits in winter-quarters in Africa and southern Asia. In our own day and country, too, wildfowl have been the subject of special inquiries into their numbers and habits; not least interesting is the increase, within living memory, of the British breeding populations of several species formerly scarce at that season. Yet again, ducks can be caught for ringing not only when young but also in decoys in winter; and they yield a good proportion of recovery records. Thus, for example, the author is able to quote descriptions of breeding harlequin (a remarkably rare visitor to us) in Iceland and of wintering garganey (one of our less common summer birds) on an equatorial lagoon; and he can cite records of ducks ringed in Britain that have travelled far into the U.S.S.R. The late George Lodge had likewise fine scope for his art in depicting the many distinctively plumaged drakes, contrasted with their relatively sombre mates; one would have liked some of the ducklings as well.

LANDSBOROUGH THOMSON

Natural Selection and Heredity

By P. M. Sheppard. Pp. 212. (London: Hutchinson and Co. (Publishers), Ltd., 1958.) 18*s*. net.

IF this book had been entitled "Natural Selection and Mendelian Heredity" with a sub-title *à la* Darwin, "Or an account of Speciation according to neo-Mendelian Principles", and had stopped at the end of Chapter 8, it could be called a good book. It is clearly written; at least, as clearly as the intricacies of the neoMendelian hypothesis will allow. But it is not certain for whom it was written. In some places it explains matter with a simplicity which is almost childish (p. 116), while at others it demands a mind of marked mathematical acuity to follow the argument (p. 107).

However, after having devoted eight chapters—just two-thirds of the book—to the "agents" which "control speciation", the author deals with protective coloration (for some reason which is obscure), with mimicry where one hoped for some modern enlightenment on this intricate problem, with a chapter of six pages on ecological genetics, and then, *mirabile dictu*, a chapter entitled "The Origin of Species". After all this there is a conclusion where it is naïvely stated that all the evidence (dealt with so superficially in the last four chapters) supports the idea that the major advances in evolution, the origin of orders, classes and phyla, are controlled by a mechanism "in no way different" from the neoMendelian tortuosities described at such length in the earlier part of the book. The fact that nowhere in the book is the origin of a new structure dealt with is overlooked. Since all the major steps in the evolutionary scale involve the appearance of entirely new structures, this surely detracts from the value of the argument. However, does this matter? The author admits the possibility of cytoplasmic inheritance (p. 171), and throughout the book deals with environmental variation (p. 63), and this, coupled with the recent statement by one of our leading neoMendelians in a review of three books, whose authors have had the temerity to write on evolution, that, of course, "the nucleus is not alone responsible for heredity", makes one wonder whether the present book has anything more than a purely hypothetical interest.

H. GRAHAM CANNON

Sixth Symposium (International) on Combustion

Yale University, New Haven, Connecticut, August 19–24, 1956. Pp. xxv+943. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957. Published for The Combustion Institute.) 224*s*.

THIS weighty volume contains 125 original papers, of which six are invited surveys and most of the rest report original work, either theoretical or experimental. Group subjects include laminar and turbulent flame propagation, fast reactions and fast flame stabilization, combustion chamber instability, ignition, combustion of liquid and solid fuels and of explosives, techniques and applications.

The publishers' work has been excellently done, but one could wish that the editors had insisted upon the provision of abstracts uniform in location and style. Many of the papers lack this feature entirely.

The meagre discussion is incompletely reported. It is scarcely fair to record critics' comments and not the authors' replies. The reverse is disconcerting. If this is the best that can be done, the space had better be saved. Reports of three panel discussions are of more interest, especially the first and most substantial on "Future Problems in Combustion Research".

Some of the papers are unsatisfactory in that the date of the Symposium rather than the state of the work has rather obviously been the factor determining publication. Despite any or all such criticisms, however, the book contains a wealth of material that will probably justify the high price in the eyes of the many workers in the field of combustion.

J. H. BURGOYNE

AN EXPERIMENTAL SOLUTION TO THE PARADOX OF DISCONTINUOUS RESPIRATION IN INSECTS

By ROBERT I. LEVY and Dr. HOWARD A. SCHNEIDERMAN
Department of Zoology, Cornell University, Ithaca, New York

IN pupæ of the Cecropia silkworm, *Hyalophora cecropia*, as in many other insects, most of the metabolic carbon dioxide is retained within the insect and released in bursts during brief periods when the spiracles are widely open, which may occur only three or four times each day[1]. Shortly after the burst of carbon dioxide, the valve at the opening of each spiracle flutters for a few moments and then constricts almost completely, remaining motionless for as long as an hour. Following this silent period, the valve begins to pulse and then flutter faintly, slightly enlarging the spiracular opening. Fluttering continues, often for several hours, until the next period of wide opening and release of carbon dioxide. Between bursts, only a trace of carbon dioxide escapes. Notwithstanding this cyclical behaviour of the spiracular valves and the resulting discontinuous release of carbon dioxide, the oxygen uptake of the pupa appears almost continuous[2]. We are thus faced with the perplexing fact that oxygen enters the pupæ during the interburst period at 6–100 times the rate at which carbon dioxide leaves. How can the spiracles, which are the sole site of gas exchange[2], allow oxygen to enter, but effectively bar the release of carbon dioxide ?

During the past five years, numerous explanations have been offered for the disparate rates of gas exchange[3]. We have even imagined a 'Maxwell's demon' at the entrance of each spiracle, which lets in oxygen but holds back carbon dioxide. Buck[4] has recently claimed that the disparate rates of interburst oxygen and carbon dioxide exchange are inexplicable on the basis of simple physical diffusion. He proposes that a partial vacuum develops within the tracheal system after spiracular constriction because oxygen is taken up faster by the tissues than carbon dioxide is given up. The possibility of such a vacuum developing within the tracheal system of an insect was first pointed out by Wigglesworth and Herford[5], who noted that the tracheal system of fleas collapsed rhythmically because of a negative barometric pressure within it. In the case of the silkworm pupa, Buck argues that the air inflow caused by the suction impedes the diffusive escape of carbon dioxide from the tracheal system. This attractive theory is unsupported by direct measurements of gas concentrations in the tracheæ (in fact, no true measurements of this sort exist), or by measurements of the time course of the supposed gas changes. To provide this information and to test the theory, we have developed techniques for measuring the composition of the gas in the pupal tracheal system during the respiratory cycle. The present article describes briefly how such measurements were accomplished and provides the first direct and repeated measurements of the composition of the tracheal gas of an insect. The measurements confirm the theory and thus resolve the paradox of discontinuous respiration.

Glass cannulæ were inserted into one or more of the fourteen spiracles of the insect to a point just beyond the spiracular valve, sealed in place with paraffin and filled with mercury. Cannulated pupæ continued to give bursts of carbon dioxide. A fine pipette was inserted into the cannula through the mercury seal and into the tracheal manifold (Fig. 1), and 0·5 mm.^{3} of gas was withdrawn from the tracheal system at intervals of 10–45 min. over periods as long as 24 hr.; the gas was analysed for oxygen and carbon dioxide with the micro-gas-analyser of Scholander[6]. Nearly one thousand such samples were obtained from about twenty *Hyalophora* pupæ, and their analyses (accurate to 0·3 per cent) revealed striking cyclical changes in the tracheal tensions of carbon dioxide and oxygen that corresponded to the cycle of carbon dioxide bursts.

The overall gas exchange of a pupa with a typical cycle of about 1 hr. duration was measured manometrically in a Warburg apparatus and is recorded in Fig. 2*A*. Tracheal gas analysis was carried out on the same pupa less than 2 hr. after the Warburg record was made. The results, Fig. 2*B*, reveal cyclical changes in tracheal carbon dioxide and oxygen tensions corresponding to the gas exchange results recorded manometrically. Gas analysis results for another pupa are presented in Fig. 3, which also reveals striking cyclical changes in the tensions of the tracheal gas.

Similar results were obtained from other pupæ, and it is clear that the cyclical changes in gas tension may conveniently be divided into three phases : (1) a period during which oxygen tension rises sharply and carbon dioxide tension falls, which we term the 'burst'; (2) a period during which oxygen tension falls steadily and the carbon dioxide tension slowly rises, which we call the 'oxygen fall period'; (3) a

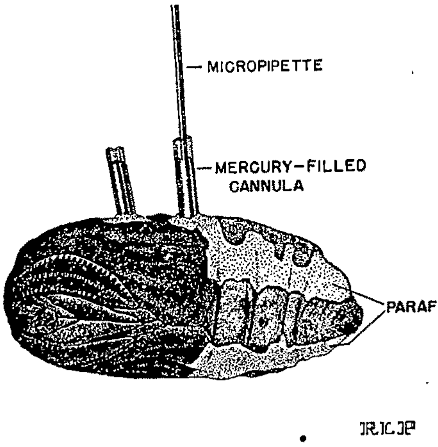

Fig. 1. Micropipette entering tracheal system of a *Hyalophora* pupa through mercury-sealed glass cannula in third abdominal spiracle. The pipette is about 0·3 mm. in diameter

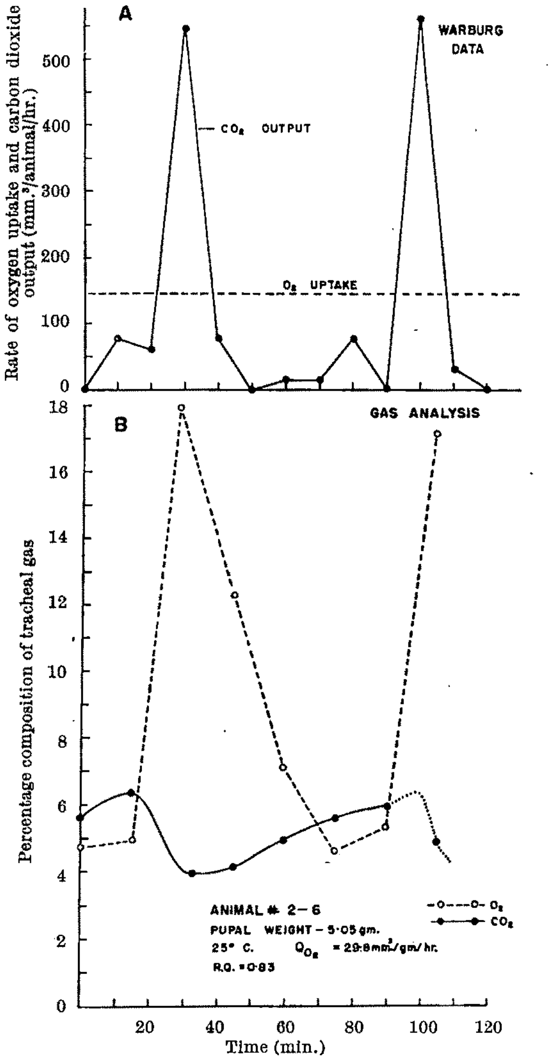

Fig. 2 (*A*) Warburg record of oxygen uptake and carbon dioxide output of a pupa. The cycles of carbon dioxide 'bursts' are clearly evident
(*B*) Record of changes in the tracheal gas tensions of the same pupa during the carbon dioxide 'burst' cycle. The two records have been given the same time axis to emphasize their correlation

period which we term the 'level oxygen period', during which oxygen tension, after suddenly ceasing its steady fall, levels off and remains fairly constant, while the carbon dioxide tension continues its slow increase.

Simultaneous records of movements of the spiracular valve and composition of tracheal gas suggest the following explanation for these cyclical changes in the latter. When the spiracular valve opens widely, carbon dioxide, which has accumulated internally, diffuses out of the tracheal system through the spiracle. Simultaneously, atmospheric air diffuses into the tracheal system, almost equilibrating the internal and the external oxygen tensions. The valve, after remaining open for a time, flutters and then constricts and lies still. With the valve in its constricted position the spiracular aperture is so small that it impedes the diffusive entry of oxygen and, as the pupal tissues respire, oxygen tension within the tracheal system drops sharply, and the tensions of carbon dioxide and nitrogen rise. Finally, oxygen tension falls to a critical threshold, which for most pupæ at 25° C. is about 3·6 per cent, and this initiates valve fluttering. This fluttering lets in enough oxygen to level off and even cause a slight rise in the internal oxygen tension. The fluttering also allows some carbon dioxide and nitrogen to escape from the tracheal system, thereby causing a levelling or slight drop in internal nitrogen tension and an almost imperceptible decrease in the rate of accumulation of carbon dioxide. During the periods of valve closure and fluttering, the internal carbon dioxide tension rises slowly and steadily from 3 per cent to about 6·4 per cent, the slowness being a consequence of the buffering action of the blood. Finally, when carbon dioxide tension in the blood and tissues (which are in equilibrium with the tracheal carbon dioxide) reaches a critical threshold, the valve opens widely, carbon dioxide diffuses out in a burst, air rushes in and the cycle begins again.

Thus the spiracular valve exhibits two distinct kinds of response to two different stimuli. Low oxygen tension causes partial, graded, relaxation of the spiracular muscle and fluttering of the valve. High carbon dioxide tension produces an all-or-none response: muscle relaxation and wide opening of the valve. Our results persuade us that, contrary to apparent doubts[7], fluttering is a normal response of the spiracle and is triggered off by oxygen tension.

This control of fluttering by oxygen tension is shown dramatically in records of valve movements at varying oxygen tensions. Oxygen tensions greater than about 50 per cent eliminate fluttering entirely and leave only the all-or-none response to carbon dioxide[1]. If the level-oxygen period is, in fact, a consequence of fluttering, as we suggest, one would anticipate that since no valve fluttering occurs in pupæ exposed to high oxygen tensions, analysis of tracheal gas would fail to reveal a level-oxygen period. This prediction is borne out in the results presented in Fig. 4, which describes the changes in composition of tracheal gases of a pupa maintained in 59 per cent oxygen. The period of decrease in oxygen tension is greatly lengthened and the level oxygen period disappears entirely. Apparently with high external oxygen tension, the tracheal oxygen tension never falls low enough to trigger off the fluttering responsible for the level-oxygen period. This result re-emphasizes that the spiracular mechanism is sensitive to lack of oxygen as well as to accumulation of carbon dioxide[8].

The present experiments provide one final piece of information. They give direct experimental support for Buck's theoretical explanation of the paradoxical disparate rates of gas exchange during the interburst period[4]. Employing the most extreme values found in our analysis of tracheal gases for the gradients for diffusive entry of oxygen and exit of carbon dioxide, a simple calculation using Fick's law of diffusion shows that these gradients would permit at most a five-fold difference in transfer-rates of diffusion. Hence we are forced to conclude that simple diffusion alone cannot account for the gas exchange of the pupa during the interburst. This conclusion, although it contradicts our usual ideas about insect respiration, is inescapable. Something other than the simple thermal agitation of molecules is responsible for driving oxygen into the insect at up to a hundred times the rate at which carbon dioxide leaves. The answer is apparently this.

When the spiracles close at the end of a burst, oxygen is used up faster than it enters, and the tracheal oxygen tensions falls. That is, the spiracular

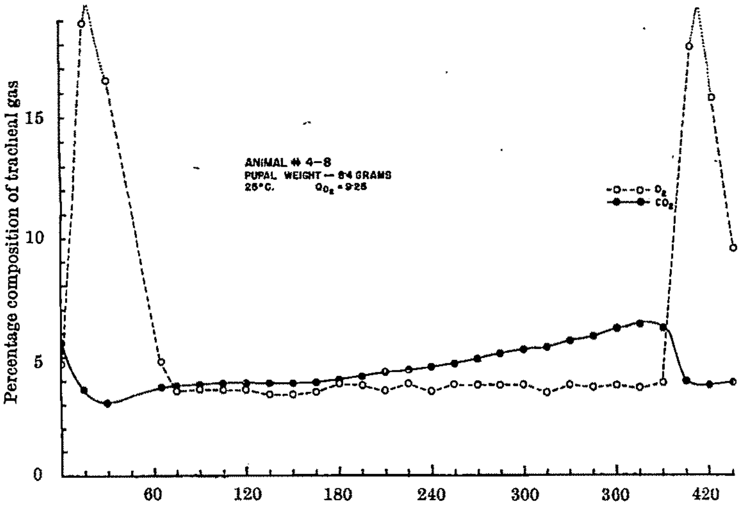

Fig. 3. Record of changes in the tracheal gas tensions of a pupa with a long carbon dioxide 'burst' cycle

openings are so small during this period of falling oxygen tension that they limit the inward diffusion of oxygen. Since a large proportion of the carbon dioxide molecules produced is dissolved and buffered by the blood, for every five molecules of oxygen used perhaps only one carbon dioxide molecule enters the tracheal gas space. This means that gradually the total number of gas molecules within the tracheal system decreases and the internal barometric pressure gradually falls. In other words, the absolute pressure within the tracheal system falls below atmospheric as the result of oxygen utilization. The consequences of this difference in pressure are tremendous. It means that through the tiny spiracular opening a stream of air will flow into the tracheal system following, not a diffusion gradient which depends on partial pressures, but a gradient of absolute pressure. In effect, the insect maintains in the tracheal system, a partial vacuum and sucks in air molecules. This mass inflow of air will not only bring in oxygen but also impede the outward diffusion of carbon dioxide and lead to a build-up of this gas within the insect that will persist as long as the spiracular opening is kept small. Nitrogen will also accumulate, since it is being sucked in with the air. Eventually, carbon dioxide accumulation in the blood triggers open the spiracles, the vacuum disappears and now gases inside and outside the insect mix by simple diffusion. Direct evidence for this postulated mass inflow of gas is seen in records of tracheal gas tensions, as the following considerations show.

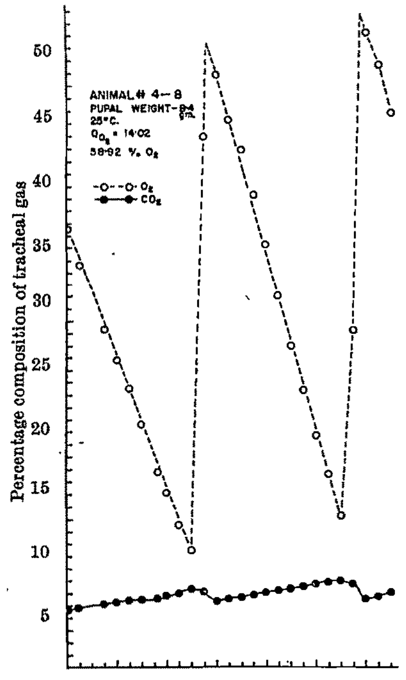

Fig. 4. Record of changes in tracheal gas tensions of a pupa maintained in 59 per cent oxygen

In Fig. 4 it is evident that during the oxygen fall period the oxygen tension within the insect falls at a steady rate which is independent of the gradient of partial pressure driving oxygen into the insect. If simple diffusion were the driving force behind the entry of oxygen, the rate of fall of internal oxygen tension would diminish as the gradient driving oxygen is increased. This is not the case. If, however, oxygen entered by mass flow, then the rate of fall of oxygen tension would remain the same during the entire oxygen fall period, because the number of oxygen molecules entering the tracheal system would be determined almost entirely by the difference in total pressure between the outside and the inside. This is borne out by the observations.

In summary, we see that for most of the time the gas exchange of the pupa is not governed, as we have long thought, by the laws of simple diffusion, in which thermal agitation of molecules is the driving force, but by a different set of laws that govern the mass transfer of gases, where the motive force is difference in absolute pressure. Since discontinuous respiration with its bursts of carbon dioxide is not uncommon among insect orders, and is found in larvæ, pupæ and adults[9], it appears that we may have to re-evaluate several of our usual motions about how some insects breathe.

We wish to thank Mr. Raphael Poritzky for drawing the figures. A detailed description of the methods and complete report of the results of the experiment is in preparation. The investigation has been supported by Grant *H*-1887 from the National Heart Institute of the U.S. Public Health Service.

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INSTITUTE OF NUCLEAR SCIENCE OF THE WEIZMANN INSTITUTE OF SCIENCE, REHOVOTH, ISRAEL

By DR. M. A. HIRSHFELD
The Weizmann Institute of Science

THE Institute of Nuclear Science, Rehovoth, is the most recently completed building of the group of scientific institutions which constitutes the Weizmann Memorial, dedicated to the memory of the late Dr. Chaim Weizmann, the first president of Israel. The memorial was established in 1952 and included the already existing Weizmann Institute of Science, the Sieff Research Institute and the Agricultural Research Station. Since its establishment, there has been added the Wolfson Building for Experimental Biology, the Wix Auditorium for lectures and scientific meetings, and the Institute of Nuclear Science. The Institute was dedicated on May 20, 1958, at a formal ceremony in the presence of the President of Israel; addresses were delivered by the Prime Minister, Prof. Niels Bohr and J. Robert Oppenheimer. The dedication was followed by a symposium in the exact sciences: among the participants were physicists from many countries, including Niels Bohr, H. C. Urey, G. Herzberg, J. E. Mayer, J. R. Oppenheimer, J. Weisskopf, S. Chandrasekhar, L. Néel and F. Bloch.

The Institute is set in the midst of the orange groves which surround Rehovoth, overlooking a spacious lawn, flower-beds and lily pond. The building is modern in style, all white, with simple rectangular lines. The main section, covering 4,600 square metres, has two floors above ground and a basement and sub-basement below. The west wing of this section houses the Department of Nuclear Physics; the east wing houses the Electronics, Spectroscopy and Nuclear Magnetic Resonance Sections, as well as the library and seminar rooms. Directly behind the Department of Nuclear Physics is a wing which houses the Department of Isotopes Research with one floor above ground and one below. Connecting the two sections is a corridor containing the common services—machine shop, electronics workshop, electrical distribution centre and administrative offices. The Van de Graaff tower is a separate structure, between the Departments of Nuclear Physics and Isotope Research, connected to both on the basement and sub-basement level. The spectroscopic laboratories are, as usual, located on the sub-basement level to reduce the amount of vibration and temperature fluctuation.

All the services are distributed to the individual rooms through the sub-basement, which extends under the entire building; the wiring and pipes are exposed as much as possible for maximum accessibility. The services include the usual gas, oxygen and compressed air, as well as vacuum and distilled water in the laboratories which require them. The electric lines supplied to outlets in each laboratory include 220 volts from the national grid, 110 volts and a stabilized 220 volts, all at 50 c./s. Free lines from the distribution centre are also connected, which can be used to supply direct current up to 220 volts, either from a generator or storage batteries, or 110 volts, 60 c./s. In Israel's climate, air conditioning is a necessity, and cooling water for this purpose is distributed from a central compressor station. Each corridor—and, in some cases, the individual laboratories—has a separate air circulation system and thermostat to control its own climate.

Because of the nature of the work, it was necessary to adopt special precautions against the harmful effects of radiation—to prevent contamination of rooms and instruments and injury to personnel. The Van de Graaff machine was isolated for this reason. The handling of all radioactive materials will be subject to centralized control. A film badge and blood-testing service will be set up to prevent excessive exposure of the scientists and technicians working in dangerous areas.

The Department of Nuclear Physics, with eight laboratories, the electronics workshop and its offices, occupies about half the main section. Most of the experimental work centres about the Van de Graaff generator, which is housed in a separate, shielded tower and is connected to the main building on the basement and sub-basement levels. The Van de Graaff is a 3-million-volt accelerator; it can deliver up to 100 microamperes and has exceptionally good voltage stability. Among the projects planned are measurements on the energy-levels of light nuclei, the investigation of Delbrück scattering and the measurement of life-times (10^{-9} sec.) of energy-levels excited by Coulomb excitation.

A method for the measurement of very short (10^{-11} sec.) life-times of excited states has been designed and built. It will be used with artificial radioactive sources or in conjunction with the pulsed beam of the Van de Graaff. It employs two beta-ray spectrometers in coincidence and uses microwave techniques to measure the time. It is being used, at present, to measure the life-time of the lowest excited state of platinum-195.

A number of theoretical physicists in the department are working on the shell model of the nucleus, using this model to correlate experimental data and predict energy-levels and transition probabilities for related nuclei. Attempts are being made, too, to develop a unified model, which would incorporate the successful features of both the shell and the collective model.

Another group is working on high-energy physics, measuring the particles ejected from 'stars' produced by 4·5 BeV. pions. The plates for these measurements were exposed to the pion beam of the Berkeley bevatron.

Theoretical work is being carried out as well on high-energy interactions—meson production in nucleon–nucleon and pion–nucleon collisions. The nucleon–pion cascade is calculated by the Monte Carlo method with the help of the Weizmann Institute electronic computer. The work is being done in collaboration with the Department of Isotopes Research.

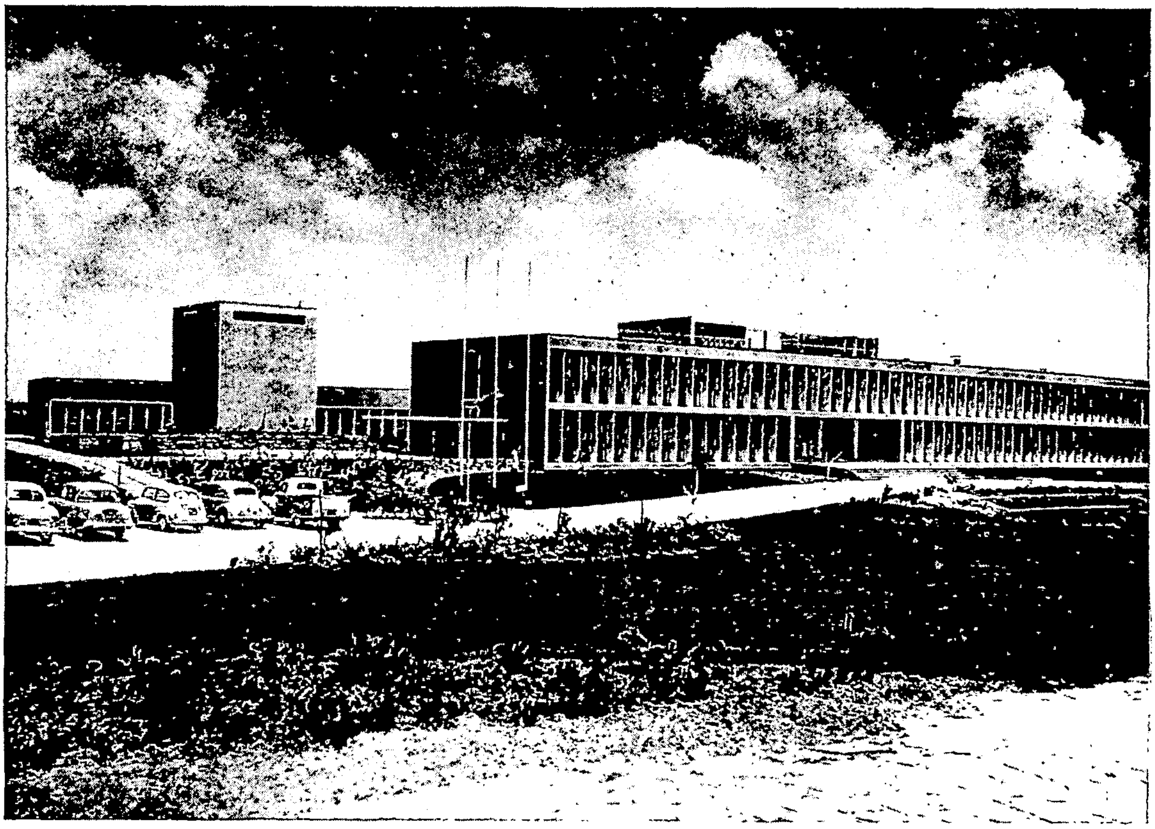

Fig. 1. The Institute of Nuclear Science, Weizmann Institute of Science

The Department of Isotopes Research occupies the rear wing of the building. It has twenty-three laboratories plus facilities for high- and low-level radioactivity work. One of its major activities has been the construction of a plant for the concentration of oxygen-17 and oxygen-18 by the multi-stage fractional distillation of water; it produces concentrations of the former up to 2·0 atomic per cent and of the latter up to 95 atomic per cent. The enriched oxygen isotopes are being used in studying such problems as the point of bond breaking in ester hydrolysis, the exchange of oxygen between organic compounds and water, and the isotope effect in the infra-red spectra of molecules. Four mass spectrometers are available for this work, two of which were constructed at the Institute.

For work with radioactive isotopes special low-level counting rooms have been built using the Faraday cage principle and low-temperature scintillation equipment with coincidence circuits. The projects being worked on include the use of carbon-14 to follow the carbon chain rearrangements during hydration of olefins, and iodine-131 to trace iodine exchange with iodo-aromatic compounds. In co-operation with the Government Water Planning Authority, a study of the flow of underground water is being made, using radiocobalt as a tracer as well as the naturally occurring tritium. A project being carried out together with the Nuclear Physics Department is the isolation of the very short-lived fission products obtained by irradiation of uranium with the thermal neutrons from the Van de Graaff generator. The Department also operates a radioisotope school for training scientists, engineers, physicians and science teachers in the applications of radioisotopes.

The Electronics Department is located in the right wing of the building and consists of nine laboratories. Its facilities comprise a 4 in. laboratory electromagnet and associated instruments built in the Department for the measurement of the magnetic properties of ferro-magnetic substances. There are facilities for the making and shaping of ferrites and standard electronic laboratory equipment.

The research done in these laboratories is in large part connected with the theory of magnetic materials and crossed-field electronic elements. A new process for magnetization reversal has been proposed in the theory of small particle magnets; it had been assumed heretofore that magnetization reversal took place by rotation in unison of the magnetization vectors of the ferro-magnetic ions. It has now been shown that processes called 'curling' and 'buckling' have lower energy and will take place. The results of this theory agree better with the known coercive forces of such magnets.

Work has been done on a crossed-field magnetic amplifier. A clip-on milliammeter based on this amplifier was constructed, and investigations were carried out on a magnetic flip-flop circuit.

Various scientific instruments have been developed in collaboration with other departments of the Institute and outside groups as well. These include several viscometers; one—a microviscometer to measure small amounts of biological substances—is now being used for research in the University of

Birmingham. Another is a high-precision couette viscometer where electrostatic forces are used to supply the restoring torque.

The Spectroscopy Section occupies eight laboratories in the basement and sub-basement of the main building. The work of the section centres around the measurement of the refractive index of gases and liquids in the infra-red. The measurement of dispersion in regions of absorption is a new approach to the problem of measuring intensities in the infra-red. It yields the same information—by an entirely independent method and possibly with improved accuracy.

Located in a laboratory in the sub-basement to provide a stable environment is the large spectrometer-refractometer for the measurement of the dispersion of gases. Designed and built at the Institute, it comprises a high-resolution grating spectrometer and a hollow-prism refractometer of very high sensitivity (1×10^{-7} index units or better); the instrument is evacuated to eliminate atmospheric absorption. Because of the high resolution and sensitivity, the refractive index can be measured through the individual lines of the rotation–vibration bands of a gas. Measurements are being made at present on diatomic gases in the 1·5 micron region and will soon be extended to longer wave-lengths.

To measure dispersion in absorbing liquids, a Perkin–Elmer infra-red spectrometer is being used, together with a specially built critical angle refractometer. Because of the complications introduced by the absorption, the Weizmann Institute electronic computer is used to reduce the results. A method has now been developed for measuring refractive indices of moderately absorbing liquids.

Also available are a large and medium quartz spectrograph for spectrographic analysis and research in the visible and ultra-violet.

The Nuclear Magnetic Resonance Section occupies four laboratories, including chemical preparation rooms. The major piece of equipment is the high-resolution spectrometer which was constructed at the Institute. It utilizes a permanent magnet with a field strength of 7,100 oersteds. The magnet is provided with field homogenizing current shims and a sample spinning turbine. The residual inhomogeneity on a sample of 0·2 cubic centimetre is 10^{-4} oersteds or less. The radio-frequency equipment is tuned to proton frequency only and a specially designed pulsing system eliminates balancing problems. A spin-echo apparatus and unit for solid-state work (a 4-in. electromagnet and Pound spectrometer) are also available.

The nuclear magnetic resonance method is being used to study the rates and mechanisms of very fast proton exchange reactions in solution. The shape of the lines is related to the mean life-time of the molecules between successive proton jumps; the measurements, therefore, enable precise kinetic data to be obtained for very high speed reactions. The reactions being studied are the *p*H-dependent proton exchange in solutions of amines, amides, hydrogen peroxide, water, etc. Work is also being done on the magnitudes and signs of spin–spin constants in liquids, on double quantum transitions, on the Maser effect and on a general theory of exchange narrowing.

NEWS and VIEWS

Applied Electron Physics at the Imperial College of Science and Technology: Prof. Dennis Gabor, F.R.S.

DR. DENNIS GABOR, who has been appointed to a newly created university chair of applied electron physics tenable at the Imperial College of Science and Technology, London, was born in Budapest in 1900. He studied electrical engineering in Budapest and Berlin-Charlottenburg, and after taking the Dr.Ing. degree entered the Siemens-Halske organization, Berlin, as research engineer in 1927. In 1934 he joined the Research Laboratory of the British Thomson-Houston Co., Rugby, and in 1949 he became Mullard reader in electronics in the Department of Electrical Engineering at the Imperial College. He was elected a Fellow of the Royal Society in 1956. Dr. Gabor's research work has covered an unusually wide field and has been characterized by a remarkable inventiveness. Few scientists can have attempted the impossible so frequently or have been so little discouraged by failure to achieve it. After working on high-speed cathode-ray oscillographs, gas-discharge lamps with positive characteristic, light-amplifiers and three-dimensional cinematography, he was attracted in 1944 by the general problem of transmitting information. He created a mathematical framework modelled on quantum theory, now known as 'structural' communication theory, which bridged the gap between the time-description and the Fourier-description of signals, and followed this by a composite of experimental excursions into waveband-saving invention and of theoretical work on the application of communication theory to physics, in particular to physical optics. He later devised a new method of obtaining optical images by 'wavefront reconstruction' which he still hopes might be applied to improving the resolution of electron microscopes. He is at present engaged on the development of a thin, flat, television tube for application to colour television. His many admirers will wish him well in this difficult undertaking.

Geography at Birmingham: Prof. R. H. Kinvig

THE retirement of Prof. R. H. Kinvig marks the end of the first thirty-four years of the Department of Geography at the University of Birmingham. He was appointed there as reader in 1924 to establish the Department, and under his guidance it has become a flourishing honours school from which have graduated several present-day holders of chairs, and a centre for geographical research, especially on the Midlands, with a fine map collection specializing in maps of Birmingham and its region. A Liverpudlian, Kinvig early developed a life-long interest in the Isle of Man, and his "History of the Isle of Man" (1944) shows his wide interest in both historical and human geography. At Birmingham he initiated local studies by his essay on the North-west Midlands for the volume on Great Britain prepared for the International Geographical Union Congress of 1928, and his own continued interest is shown in his editorship of the British Association volume on Birmingham (1950), and his work on the Domesday geography of Warwickshire. He has also travelled widely, and his resulting writings have done much to stimulate studies in Latin America, Poland and southern Africa. His services to the University were recognized by the conferment of a professorship in 1950 and to his subject by his election to the presidency of Section E of the British Association (which he long served as recorder) in 1953, and the presidency of the Institute of British Geographers in 1957.

Prof. David L. Linton

Prof. D. L. Linton, who has held the chair of geography at Sheffield since 1945, has been appointed to succeed Prof. Kinvig at Birmingham. He is now among the most senior of those who graduated from the new honours schools of geography established after the First World War, taking first a general degree in science and then a special degree in geography in 1927 from the Joint School of Geography of King's College, London, and the London School of Economics. He shares with his former teacher and life-long friend and associate in research, Prof. S. W. Wooldridge, an especial interest in geomorphology. He was appointed to the chair at Sheffield at the age of thirty-eight (*Nature*, 106, 106 ; 1945) after service in his old college, King's, and Edinburgh, and a distinguished career in the R.A.F.V.R., where his special talents were used in photographic interpretation. There, as in all his later work, his critical and incisive thinking often resulted in new and fresh interpretations of familiar features. This is seen in his work on delimitation of morphological regions, on drainage patterns and the origin of tors, and in his presidential address to Section E of the British Association in 1957. His long and unobtrusive service as honorary editor of *Geography* is reflected in the current high standing of that journal. Before taking up his duties in Birmingham he is spending a year on research in the Falklands.

Space Science Board

The U.S. National Academy of Sciences has announced the formation of a sixteen-man Space Science Board, "to survey in concert the scientific problems, opportunities and implications of man's advance into space". Dr. Lloyd V. Berkner, president of Associated Universities, Inc., president of the International Council of Scientific Unions and a member of the National Academy of Sciences, is to be the chairman. The Board, besides acting as the focal point for all Academy and National Research Council activities connected with space-science research, will be called upon to co-ordinate its work with appropriate civilian and government agencies, particularly the proposed National Aeronautical and Space Agency, the National Science Foundation, and the Advanced Research Projects Agency, and with foreign groups active in this field.

Darwin, Demography and Development of Life

Three outstanding lectures have now been made available to bigger audiences. The first, by Sir Gavin de Beer, is his well-known lecture on Charles Darwin in the Master-Mind Series of the British Academy (pp. 24. Oxford University Press, 1958. 3*s*. 6*d*.). Besides a succinct introduction to Darwin's life and thought, the lecture provides an admirable exposition of the pre-eminent place of natural selection among contemporary theories of evolution. The second, by the grandson of the genius whom de Beer honoured in his lecture, is the 1958 Rede Lecture, in which Sir Charles Darwin expounds the belief that the present rapid increase in world population holds threats for the future outweighing completely any of the menaces that preoccupy statesmen and politicians (pp. ii+42. Cambridge University Press, 1958. 3*s*. 6*d*.). The third is the inaugural lecture by the recently appointed Quain professor of botany in the University of London, Prof. David Lewis ("The Experimental Approach to Life". Pp. 17. London: H. K. Lewis and Co., Ltd., 1958. 2*s*. 6*d*.). In his lecture, Lewis discusses the experimental approach to life, and shows how physics and chemistry are beginning to play an equally important part with biology. The invasion of biology by physics and chemistry has created a crisis that must be resolved by all who are concerned in biological teaching and research. In research the crisis is partly met by establishing departments of biochemistry and biophysics, but this does not solve the immediate problem of training biologists, which must be carried out in departments of botany and zoology.

Oversea Visual Aids Centre, London

As a result of the unanimous request of an Oversea Visual Aids Conference held in 1956, a Centre has been set up in London from which advice and help will be given on all aspects of audio-visual aids. The Centre, which is to be known as the Oversea Visual Aids Centre (O.V.A.C.), is sponsored by H.M. Government and the Nuffield Foundation. Its director is Mr. G. H. Busbridger, who served in the Educational Service in Northern Rhodesia for many years and afterwards became director of Education in Tanganyika Territory. The Centre has started its activities at Tavistock House, Tavistock Square, London, W.C.1, while alterations are being made to premises at 31 Tavistock Square, which will become its permanent headquarters towards the end of the year. The Centre is controlled by a Board of Governors under the chairmanship of Mr. L. Farrer-Brown, director of the Nuffield Foundation. The Centre will have on permanent display a wide range of projected and non-projected aids, so that visitors can see for themselves examples of the latest equipment used by British manufacturers, as well as cheap non-projected aids made from local materials. It will organize training in the educational use of all kinds of audio-visual aids, in the handling and maintenance of equipment and in techniques of making simple aids from cheap materials. In addition to these services, Governments and individuals overseas will be kept informed of new developments by regular publications.

River Pollution in Britain

In its first report to the Central Advisory Water Committee (pp. 10. London: H.M. Stationery Office, 1958. 9*d*. net), the Trade Effluents Sub-Committee, appointed in October 1956 with Sir Frederick Armer as chairman, to examine existing legislation and the operation of the common law respecting the disposal from trade premises of liquid effluents, concludes that the time has not yet arrived for dispensing with the consent of the Minister of Housing and Local Government before river boards can prosecute for pollution of rivers. It recommends accordingly that the original seven-year period of the Rivers (Prevention of Pollution) Act, 1951, should be extended from 1958 to 1961. In the report, which has been unanimously adopted by the main committee, the sub-committee concludes that, while it is true that river boards generally have shown forbearance, in view of the financial implications of their requirements on industry as well as on local authorities, and through them on the country as a whole, they ought not to disregard the fears of those who are concerned lest they be caught between the difficulties of capital restriction on one hand and possible prosecution on the other. It also seemed desirable to allow a little extra time to industry to pursue research on effluent treatment and to river boards to prepare by-laws laying down permissible standards for effluents. The Committee remarks that it is now embarking on its general review of the law on this subject.

Aslib : Report of the Council

THE report of the Council of the Association of Special Libraries and Information Bureaux for the year ended December 31, 1957, presented at the annual general meeting of Aslib on June 3, records a further increase in membership, from 2,095 to 2,254, including twenty-six technical colleges. Industrial and commercial firms still form the largest single category, totalling 831, compared with 753 at the end of 1956. Besides the acquisition of new and larger premises (3 Belgrave Square, London, S.W.1) which should permit Aslib to develop a research section, establish an exhibition of equipment for library and information work, and expand its library to serve also as a laboratory for testing and demonstrating library equipment and processes, several new short courses were organized during the year, including those on advanced classification, the handling of Russian and other East European literature and the treatment of periodicals. Three special conferences held in London dealt with library services in technical colleges, the preservation of business records and the availability of information on nuclear energy. A grant of £10,000 was received from the National Science Foundation to finance a two-year research project into the efficiency of selected indexing systems, while, with the Royal Society, Aslib is co-ordinating British participation in an International Conference on Scientific Information to be held in Washington in November 1958.

Forest Products Research Laboratory

THE Council for Scientific and Industrial Research has decided that research on the following subjects should be undertaken at the Forest Products Research Laboratory: (1) the pulping properties of home-grown timbers; (2) more work on the general properties of home-grown timbers. An additional scientific officer will be appointed to take charge of the work on pulping. Otherwise all the staff required are to be provided by transfer from other existing work at the Laboratory. The Research Council has also decided that it is not possible to continue indefinitely at the public expense all the work which is at present carried out on timber bending, wood working, composite wood and wood protection. The value of the work is not questioned, but it is considered that the industries concerned which benefit from the work should do it themselves, or pay for it to be done. The Department is therefore informing the industries concerned that its expenditure on work in these fields will diminish progressively and will end in five years time. It will thus be open to industry to carry out the work or to pay the Forest Products Research Laboratory to do it.

Yale Medical Library

THE annual report of the Yale Medical Library for 1956–57, which includes the report of the Historical Library, covers the year ended June 30, 1957 (pp. 33. New Haven, Conn.: Yale University, 1957), and records an increase of more than 160 per cent in the endowed book funds, income from which now approaches 10 per cent of the amount appropriated for purchasing books and periodicals. The film-room maintained by the Library, together with the Audio Visual Centre, seats fifty people, and now contains a 16-mm. sound projector, a slide projector and a microfilm reader, and its use has steadily increased. Accessions of 6,161 during the year brought the Library's holdings to 295,252 volumes (including books, pamphlets and serials) and 26,469 volumes were circulated for outside use, besides 1,055 in inter-library loans. The Library, which has an outstanding collection of Western manuscripts, is one of the foremost in the United States in the richness of its collections for the physician, the scientist and the historian.

Royal College of Science and Technology, Glasgow

THE annual report of the Royal College of Science and Technology, Glasgow, for the year 1956–57, records the initiation of no major developments during that year. During the next ten years the University Grants Committee wishes the College to provide for a student body rising to 2,500. During the quinquennium 1957–62, developments on the teaching side will be mainly to cope with the larger numbers, reduce the size of classes and increase the facilities for advanced study and research. In the reports from Departments, reference is made to the study in the Department of Mathematics of the diffusion of momentum when a jet issues into an outside medium, and the variation of concentration when the jet and the outside medium consist of gases of different kinds; to a varied programme of research in the Department of Natural Philosophy, including an examination of strains of the bacterium *Proteus vulgaris*, and completion of an investigation on the transmission and absorption of highly reflecting films; extension of the research on paddle wheel propulsion in the Department of Naval Architecture, in conjunction with William Denny and Bros., Ltd., by an investigation of the relation between the model results and those from ship trials. In the School of Pharmacy a new series of neuromuscular blocking agents was prepared. A list of recent publications is also included, but further information on research in progress in the various departments is contained in the Report on Research for the Session (pp. 39. Glasgow: Royal College of Science and Technology, 1958). This lists publications departmentally, with a brief abstract of each.

Publications of the Oak Ridge National Laboratory

A LIST of articles in scientific and technical journals and of unclassified reports published during 1957 by members of the staff of the Oak Ridge National

Laboratory has recently been issued (Pp. v+34. Oak Ridge National Laboratory, Union Carbide Corporation, 1958). The articles and reports are listed in separate sections and classified in alphabetical order of authors under the general headings: biology, chemistry, engineering, general, health physics, instrumentation, mathematics, metallurgy and materials, and physics. Many of the papers are available free as reprints from the Central Research Library, Oak Ridge National Laboratory, P.O. Box *X*, Oak Ridge, Tennessee, and others may be purchased through the Office of Technical Services, Department of Commerce, Washington 25, D.C. Some articles were published in 1956, but were not issued until 1957; the 1956 and 1957 articles are distinguished by the prefixes '56' and '57', respectively, before the reference numbers. The authors' names, title of paper and journal reference are given in every case.

Alkali Works in Britain

The ninety-fourth Annual Report on Alkali, etc., Works in England and Wales (pp. 50. London: H.M. Stationery Office, 1958. 3*s*. net) by the Chief Inspector covers the year 1957, when the number of works registered decreased by seventeen to 872 and the number of processes by fourteen to 1,733, due to the concentration of manufacturing operations, particularly at gas-works and by-product plants. The 4,023 units and inspections during the year included 174 special visits by the chief and deputy chief inspectors and nine by Mr. W. A. Damon, who since March has been engaged on special advisory duties. Of the total, 430 visits were to or in connexion with works not registered under the Act, and a further 55 visits were in connexion with colliery spoilbanks. Besides 2,175 quantitative analyses made of gases evolved from the processes in question during the inspections, 965 samples were submitted for detailed examination to the Government Chemist. Complaints were most numerous against cement works and fertilizer granulation plants, and escapes of fumes in excess of statutory limits were recorded on seven occasions, a further ten infractions related to failure to use the "best practical means", the total infractions comparing with 23 in 1956 and 48 in 1955. A general survey of emissions of smoke, grit and dust from registered operations indicated that reasonably satisfactory conditions already exist generally.

Under the same cover is included the annual report for 1957 of the Chief Inspector for Scotland, where the number of registered works decreased by nine to 71 and of processes requiring inspection by thirteen to 101. In the 148 visits of inspection, 56 chemical tests were made. Of the five complaints lodged about fumes from registered works, three related to granulated fertilizer plants and two to paraffin oil works.

Industrial Research in East Africa

The annual report for 1956–57 of the East African Industrial Research Board (pp. ii+8. Nairobi: Government Printer, 1957. Sh. 2) records continued trials on the production of vitreous white-ware bodies, and attempts are now being made to adapt the process to native industry. In the manufacture of bricks and tiles, relatively large additions of sawdust have been possible to some clays, probably those containing a fusible lava, with consequent increased fuel economies, and a pilot-scale continuous kiln has been designed for reconstituting meerschaum from the waste in producing tobacco pipes. Research continued on the mechanical drying of arabica coffee, and fair results have been obtained in estate practice by two methods which should cause no more damage to quality than sun-drying under difficult conditions. Fully wet coffee is severely damaged by a single-stage drying about 100° F., but the damage is less the lower the initial moisture content at which mechanical drying starts. Serious damage to quality is probably associated with damage to viability. In chemical engineering a preliminary investigation has been made on the possibility of condensing natural steam with a jet condenser or an air-cooled surface condenser, and work has commenced on the use of pressure charges for internal combustion engines and on the economies of drying sisal waste. A further attempt to operate a 40-gallon digester for producing methane from sisal waste failed.

East Malling Research Station

An index has been published to provide quick and adequate reference to work carried out at East Malling Research Station and mentioned in the annual research reports since 1913 (Kent Incorporated Society for Promoting Experiments in Horticulture. Abstracts and Index to the Annual Research Reports, 1913–1953, East Malling Research Station, near Maidstone, Kent. Pp. vi+175. East Malling: East Malling Research Station, 1957. 20*s*.). This alone will prove useful to all those concerned with fruit-growing and plantation crops, but the value of the work is greatly enhanced by the fact that the compilers, Dr. F. W. Andrews and Mr. A. C. Painter, have also given a brief abstract of each paper. Thus, a great volume of information has been made available without laborious search. There is an appendix of the pests and diseases mentioned in the reports, under their common English names with their scientific equivalents, including synonyms.

Lundy Field Society

The saddest feature of the eleventh annual report of the Lundy Field Society (Lundy Field Society. Eleventh Annual Report, 1957. Pp. 43+2 plates. Exeter: Prof. L. A. Harvey, The University, 1958. 5*s*.) is the reference by the president, Albion P. Harman, to the real decline in the numbers of puffins on the island. The possibility of the puffin disappearing from the island appears to be very great; within a few years it seems unlikely that the bird will breed there. This is almost certainly due to oil pollution of the sea. Another reference in the report is to the remarkable invasion of tits which took place in October 1957. The immigrants included blue tits, coal tits and great tits, and their times of arrivals coincided with similar records made in other parts of Great Britain. Seven birds new to the island were recorded during 1957; these included the little egret, American stint, tawny owl, nightingale, Richard's pipit and red-knecked grebe. A new feature in the report is an account of the many mesolithic flints unearthed by members of the Devonport High School during a stay on the island. The collection included a number of small worked microlithic blades, a microburin, conical cores, several notched blades, and a fine backed burin or graver, all typical of a mesolithic culture, although possibly of a late date.

A Schoolboy's Survey of Vegetation of a Valley

Blundell's School, Tiverton, may well be proud of R. G. Pembrey, who was awarded the Senior Batterbee Prize in 1957 for an investigation into the factors underlying the differences in vegetation on the north- and south-facing slopes of a steep valley in spring. Pembrey compared the vegetation on the two slopes, analysed the soils at different levels and made observations on the bedding plane of the rocks, recorded environmental factors like soil, temperature and light intensity and made various records comparing the performance of different species on the two slopes. These included the rate of elongation of stems of bramble and yellow archangel, the internode length in ash seedlings, and the times of bursting of beech buds. The differences in the vegetation on the two slopes are due to a more rapid warming of the soil on the south-facing slopes, which allows the growth of a spring ground flora before the bursting of the beech buds. This is directly connected with the far higher light intensity on this slope. On the opposite slope, light intensity and soil temperatures are too low to support a spring flora. A full report of the investigation is described in the *School's Science Magazine,* which contains reports of other interesting work by schoolboys.

Volcanic Eruptions in Kamchatka

The extinct or dormant volcano Bezymyannyi (also known as Sopka Bezymyannaya), belonging to the Klynchevsky group of volcanoes of Kamchatka, revived its activity on September 29, 1955, in the form of a series of volcanic earthquakes, followed on October 22, 1955, by eruptions terminating, on March 30, 1956, in a gigantic explosion which removed the greater part of the cone and formed a new crater-caldera. The progress of this activity was observed by G. S. Gorshkov and his companions and is described by him in two articles (*Bull. Volcan. Station,* No. 26, *Acad. Sci. U.S.S.R.,* 1957 ; *Priroda,* 1, 61 ; 1958). The violent explosions of this volcano gave rise to large masses of volcanic ash which, mixing with melting snow, formed a series of mud flows, some 60 km. in length with a calculated volume of 3 cubic kilometres. These flows became covered with a large number of secondary fumaroles in such a way that the whole district resembled the Valley of Ten Thousand Smokes of the Katmai eruption of 1912 in Alaska. According to Gorshkov, the calculated total energy of the volcanic explosive activity was 4×10^{23} ergs, while the total thermal energy evolved was $3{\cdot}6 \times 10^{25}$ ergs. This shows that the force of the eruption was due to the thermal energy of the magma and that the gas acted mainly as the transformer of the thermal energy into the explosion energy. During the final stages of the eruption a large plug-dome of andesitic lava was intruded in the crater-caldera of the volcano.

Reduction of Evaporation from Reservoirs

In an article in the *World Meteorological Bulletin* of April 1958 and in a report on the use of cetyl alcohol in solution to reduce evaporation from reservoirs Mr. F. Grundy gives an account of an experiment conducted on Malya reservoir in Tanganyika Territory during August 1957 (Memoirs of the East African Meteorological Department, 2, No. 11 ; 1958. Nairobi : East African Meteorological Department, 1958. Sh. 4). The subject is one of particularly great importance in tropical areas where loss of water by evaporation can be several times the volume drawn for use. The work in East Africa began with tests in evaporation pans in the grounds of the Meteorological Office at Nairobi, which showed reduction of loss by about 60 per cent. Work on the Malya reservoir (130 acres) was more difficult because of disturbance by wind, and it was found better to use the alcohol dissolved in such solvents as kerosene rather than in solid form. The solution has to be applied continuously from sources on the upwind shore or preferably, because of better adjustment to wind changes, from a boat. The observations were made during the dry season to avoid complications due to rain. By computing the evaporation-loss from the inflow and outflow and comparing with evaporation from neighbouring evaporation pans it was estimated that the evaporation-loss was reduced by 11 per cent. The amount of cetyl alcohol used was 18 lb./day. It is not poisonous to man or animals, but its effects on fish are not yet known. Mr. Grundy considers that the experiments show an adequate film of cetyl alcohol can be maintained, but that further research is needed, especially on the method of applying the substance and avoiding wastage from its oxidation by organic matter. The cost is not likely to be excessive.

Nomenclature of Cultivated Plants and of Fungi Pathogenic to Man

It is now generally accepted that agreed international codes of nomenclature are essential to progress and unity of effort in the biological sciences ; and cultivated plants, being essential to civilization, should be brought fully within "a precise, stable and internationally accepted system". So states Article 1 of "The International Code of Nomenclature for Cultivated Plants" (1958), now published by the International Bureau for Plant Taxonomy and Nomenclature of the International Association for Plant Taxonomy (106 Lange Nieuwstraat, Utrecht, and Royal Horticultural Society, London. 2*s.* 6*d.*). In this short but valuable publication, to which many distinguished botanists have contributed, all relevant issues are considered with clarity and precision. In the same general category, but dealing with very different subject-matter, the Medical Research Council has now published a revised edition of Memorandum No. 23, first issued in 1949 ("Nomenclature of Fungi Pathogenic to Man and Animals—Names recommended for use in Great Britain". Second edition. Pp. iii+14. London: H.M. Stationery Office, 1958. 1*s.* 3*d.* net). Here, again, it is noted how much progress in medical mycology has been hindered by the multiplicity of names for fungi associated with certain human and animal diseases. The nomenclatural issues here can be very complex indeed, and both knowledge and judgment are essential to sound decisions. In this small pamphlet an exacting task has been ably performed.

Peruvian Orchids

The Orchidaceae not only vie with the Compositae as a family comprising a vast number of species—somewhere between 15,000 and 35,000 according to contemporary estimates—but they are also undoubtedly among the most advanced group of the monocotyledons. A further contribution to our knowledge of this family comes from Peru, where some 120 genera and 900 species have been recorded. A recent publication deals with 26 genera and 629 species (Chicago Museum of Natural History. *Fieldiana*: *Botany*. Vol. 30, No. 1: Orchids of Peru. By Charles Schweinfurth. Pp. viii+260. (Publication 837.) Chicago: Chicago Natural History Museum, 1958. 4.50 dollars). In the Peruvian and Colombian Andes, indeed, the orchid flora apparently reaches its richest expression. As the author points out, although there have been many collecting expeditions to the Peruvian Andes, and much material stored away in herbaria, no comprehensive flora of the region has been undertaken for 130 years. The monograph is well illustrated by line drawings.

Biology in the Far East

A Congress has been arranged by the University of Malaya, to be held in Singapore during December 2–9, to celebrate the centenary of the publication of the theory of evolution by Charles Darwin and Alfred Russel Wallace, and the bi-centenary of the publication of the tenth edition of "Systema Naturæ" by Linnæus, and to provide a forum for scientists in South-East Asia who were not able to attend the fifteenth International Congress of Zoology in London in July. Recognition has been given to this Congress by various learned societies which have nominated representatives to attend and contribute papers to the symposia. Financial support has been gained from numerous sources, whereby it has been possible to issue invitations to a number of biologists in various parts of the world to attend the Congress as guests of the University of Malaya. Valuable help is also being given to the organization of relevant exhibitions. The organizers of the Congress hope to enable some distinguished visitors to visit the Federation of Malaya to deliver additional lectures at appropriate places, and it is also expected that the various exhibitions will be sent into the Federation of Malaya for display, so that the maximum benefit can be gained from the occasion.

The Congress will open on December 2 with an address of welcome to the visitors, and a presidential address, followed by lectures introducing the Indo-Malayan region, and the concept of organic evolution. The following six days will be devoted to a series of symposia in the fields of botany, ecology, general systematics, evolution, genetics and anthropology. Visits to local places of interest will be arranged during December 2–9, and a number of excursions will be held immediately afterwards.

Prospective participants should communicate the title of any scientific paper offered, with its length, to Prof. R. D. Purchon, University of Malaya, Singapore, from whom further information can be obtained.

U.S. National Science Foundation: Senior Postdoctoral Fellowships

The National Science Foundation, Washington, D.C., has announced the award of 54 science faculty fellowships for the academic year 1958–59, offered as a means of improving the teaching of science, mathematics and engineering in American colleges and universities. The Foundation has also announced the award of 27 senior postdoctoral fellowships in the sciences for the academic year 1958–59, selected from 155 applicants. Science faculty fellows were selected from 440 graduates from all parts of the United States and its territories on the basis of demonstrated ability and special aptitude for science teaching and advanced training. Senior postdoctoral fellowships were awarded to scientists with ability and special aptitude for productive scholarship. Ten awards were made in the life sciences, and fifteen in the physical sciences, including a number in inter-disciplinary fields. Two awards were made in convergent fields. Science faculty and senior postdoctoral fellowships carry stipends approximately equal to the regular salaries of the recipients. These stipends may be applied towards study or research in an accredited non-profit institution of higher learning in the United States or abroad.

Announcements

The ninth International Congress on Astronautics will be held in Amsterdam during August 25–30. Further information can be obtained from the British Interplanetary Society, 12 Bessborough Gardens, London, S.W.1.

The Golden Jubilee Autumn Meeting of the Institute of Metals will be held in Birmingham during September 22–26. Further information can be obtained from the Secretary, Institute of Metals, 17 Belgrave Square, London, S.W.1.

The next joint meeting of the Challenger Society and representatives from the Marine Laboratories (Development Commissioners' Scheme) will be held at the Dove Marine Laboratory, Cullercoats, and King's College, Newcastle upon Tyne, during September 18 and 19. Further information can be obtained from Dr. H. O. Bull, Dove Marine Laboratory, Cullercoats, North Shields, Northumberland.

The fourth Reinforced Plastics Technical Conference, organized by the British Plastics Federation, will be held at the Hotel Metropole, Brighton, during October 21–24. There will be sessions on the properties of basic materials, applications, manufacture and user interests. Papers will be preprinted and circulated before the conference. Further details can be obtained from the British Plastics Federation, 47–48 Piccadilly, London, W.1.

The British Weed Control Conference, 1958, organized jointly by the Society of Chemical Industry and the British Weed Control Council, will be held at the Hotel Metropole, Brighton, during November 3–6. Further information can be obtained from the Assistant Secretary, Society of Chemical Industry, 14 Belgrave Square, London, S.W.1.

The National Institute of Agricultural Botany is holding a conference on "Herbage Seed Production" in Cambridge during November 18 and 19. Further information can be obtained from the Secretary of the Institute, at Huntingdon Road, Cambridge.

The Artemis Press invites submission of manuscripts for a prize of £150, which will be awarded for an academic work in mathematics, astronomy or physics. Both monographs and more general works will be considered; they need not be original in content, but relevance to fundamental topics and elegance of treatment are desirable. All manuscripts submitted will be considered for publication. Further information and entry forms can be obtained from the Artemis Press, Ltd., 25 Walpole Street, London, S.W.3.

GEOLOGICAL MAP OF THE WORLD

THE Commission for the Geological Map of the World met in Paris during March 31–April 12. This Commission was founded in 1910 at the Stockholm International Congress and has been reorganized twice since the Second World War. At the Mexico International Geological Congress in 1956 two Sub-Commissions were created: (1) for the Tectonic Map of the World, and (2) for the Metallogenic Map of the World. The Paris meeting was organized to establish an international basis and co-ordination for an immediate start on these three maps of the World: geological, tectonic and metallogenic, on an agreed universal scale, legend and principles of construction. The Commission's aim is to promote the construction of such maps for the following regions of the Earth: North America, South America, Europe, Africa, U.S.S.R., Asia, Oceania, Arctic and Antarctic. The Commission is planning to publish a Geological Atlas of the World at the scale 1 :10,000,000 based on maps at the scale of 1 : 5,000,000. The latter scale is suggested for the tectonic and metallogenic maps. Detailed programmes for the realization of these maps were worked out by the Commission and a number of specific recommendations from various countries or groups of countries were accepted. The aim of the metallogenic map is to record the relations between geology, tectonics and the mineral deposits in any given region. It was also suggested that prior to the construction of such maps, mineral maps accompanied by indexes of mineral deposits should be prepared. It is hoped that these maps, at least in manuscript draft form will be ready for display at the International Geological Congress to be held in Copenhagen in 1960.

Sixty-one countries were represented at the Paris meeting by delegates and assisting geologists. The president of the Commission, elected in 1952, is F. Blondel, who is assisted by his secretariat at 20, rue Monsieur, Paris 7^{e}, France. The vice-presidents for the selected regions are as follows: North and Central America, W. D. Johnston, jun.; South America, A. R. Lamego; Europe, A. Bentz; Africa, F. Dixey; U.S.S.R., N. A. Beliaevsky; Asia, V. P. Sondhi; Oceania, J. M. Rayner.

A Select Committee under the presidency of F. Dixey examined suggestions for the general legend of the Geological Map of the World and drafted a set of recommendations. Similar work was done for the tectonic map by the special sub-commission (president, N. S. Shatsky; secretary, A. A. Bogdanov), and for the metallogenic map by the special sub-commission (president, W. D. Johnston, jun.; secretary, P. Routhier). Possibilities of preparing a coal map of Europe were also discussed.

Besides the meetings of the Commissions, a number of meetings dealing with various associated problems were held, such as the International Geological Abstracting Service, presided over by H. M. E. Schurmann, the Committee on Stratigraphy, the Mediterranean-Alpine Committee and others.

During the fortnight's working of the Commission, a number of official receptions were held, which allowed a closer contact between the visiting geologists and their French colleagues, and the strenuous work of the Commission was relieved at the week-end by a visit to the cathedral towns and the castles of the Loire region. The meeting of such a number of geologists from so many countries, animated by the same enthusiasm and purpose, testifies to a most healthy situation in the world of international science. The effective and profitable results of the meeting are, in no small measure, due to the most efficient organization of the Commission by its president and secretariat.

MUSEUMS ASSOCIATION CONFERENCE

THE sixty-fourth annual conference of the Museums Association was held in London during July 7–12, and was attended by more than 700 delegates, among whom were some 70 members of De Museumdag from Holland. It was held in Britain to enable the British delegates to return in some measure the hospitality and courtesy extended to them on their visit to Amsterdam in 1956.

The meetings were held in the Beveridge Hall of the University of London and the official welcome was given by the Minister of Education (the Right Hon. Geoffrey Lloyd), who stressed the view of his Ministry that there should be more co-operation between local authorities and private bodies in the maintenance of museums. He welcomed the increasing part that museums were taking in the educational field and said that the Government was well aware of the difficulties of the small museum. Various suggestions had been made and meanwhile his Ministry was watching with interest the development of plans for a regional museum service.

During his presidential address Sir Philip Hendy, director of the National Gallery, dealt with various problems in the museum and art gallery field. First, he mentioned that the tremendous assistance given by the Carnegie United Kingdom Trust in the past is likely to be reduced in the future. He expressed the strong opinion of the Association that it should be replaced by Government assistance of a substantial nature. He then dealt with the recent controversy arising from the enlightened provisions of the Finance Act, 1956, whereby works of art could be accepted in payment of death duties. It was discouraging that a difference had arisen between local and national claims over the Chatsworth treasures. He believed that objects of the highest quality should go to the national collections, as they and they alone could provide the proper context and setting for such material. He also felt that the provisions of the Finance Act could be used for other objects that would be useful in building up the collections of local museums and would otherwise be almost certainly exported from Great Britain.

Dr. A. B. de Vries, president of De Museumdag, also spoke and enumerated some of the qualities necessary in a museum curator.

A complete session was given to a discussion concerning museums in the Commonwealth and Overseas with especial reference to the training of curators. Dr. D. B. Harden, chairman, in opening the discussion, referred to the progress that had already been made with training schemes in South Africa and Canada and expressed the hope that an overseas secretary would be appointed at no distant date to deal with the furtherance of international relationships between the home country, the Dominions and other smaller countries within the Commonwealth. Subsequent speakers included professional museum staff from parts of Africa, Pakistan and Singapore. It was stated by Prof. P. L. Shinnie of the University of Ghana that countries which had recently achieved their independence would not be content with having their museums staffed by English people. On the other hand, Africans with good degrees would scarcely be willing to accept museum posts when there were far more attractive openings in the Civil Service. He felt that the training of technicians could be dealt with in Africa but that curators should have the benefit of a European tour of representative institutions. Dr. L. S. Russell, secretary of the Museums Association in Canada, stated that an inquiry had, contrary to the accepted idea, shown that the chief difficulty in that country was not geographical separation but diversity of subject-matter.

Another session, under the chairmanship of Dr. W. E. Swinton, was devoted to museum architecture. It was opened by Mr. Sheppard Fidler, city architect of Birmingham, who described in detail the reconstruction of the galleries which had been so severely bombed during the War. Dr. H. L. C. Jaffé, Amsterdam, dealt with the many building schemes which had taken place in Holland and several other speakers contributed to the discussion.

In proposing a resolution which deplored the continual negative attitude of H.M. Government towards granting assistance to local museums and art galleries, and urging that everything should be done to acquaint those in authority and others with the facts, Sir Mortimer Wheeler felt that the Standing Commission was an eminent body but of no service to provincial museums. He stressed the urgent need for analytical information and considered that a Royal Commission on the whole subject was long overdue. Government help on a modest scale was needed, and he felt an analogy with the successful University Grants Committee was sound and could be fruitful.

At the annual general meeting, Dr. W. E. Swinton, British Museum (Natural History), was elected president and Sir Philip Hendy and Prof. Lionel Robbins vice-presidents for the ensuing year.

A successful feature of the conference was the large number of working parties which had been arranged at the larger museums and art galleries in London. These were much appreciated by both the Dutch and British delegates and led to many useful discussions in which small groups benefited greatly from the expert knowledge of the staffs concerned.

Receptions were on a lavish scale and included an evening one at the National Gallery which was graced by the presence of Her Majesty Queen Elizabeth the Queen Mother, patron of the Museums Association, a spectacular reception at the Guildhall given by the Corporation of London and smaller groups at the Wellcome Historical Museum of Medical Science and the Iveagh Bequest, Kenwood. The annual dinner was held at the Goldsmiths' Hall and the conference concluded with field meetings at Brighton, Petworth House, Saltwood Castle and Canterbury, Cambridge and St. Albans. It was decided to hold the next conference in Worthing during June 15–20, 1959.

THE BACKGROUND TO SPECIALIST TECHNOLOGICAL EDUCATION

By Dr. M. L. R. PETTERSSON
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HOW does, how *should*, the content of a course for the diploma in technology differ from that of a traditional honours degree course ? It is the present purpose to attempt, in part, to give an answer to this question. The tradition of technical education, often by apprenticeship, can be traced back to the earliest stages of human society. The educational tradition of scholarly book learning, on the other hand, has evolved only in the past 1 per cent of human existence. The medieval universities and schools took their character almost entirely from the scholarly tradition. Yet it is by a blending of these two kinds of activity that the flowering of modern science has arisen; to produce the change from the agricultural to the industrial stage of human society.

To what extent is present-day education adapted to the needs of our children, in contemporary industrial society ? We have in Britain, comparatively, an extremely good educational system. But since society is developing with such rapidity, both recent reforms and further changes appear inevitable. Confining attention to grammar school and college education, the following five points are offered for consideration.

(1) At the Renaissance, attention to ancient writers was a progressive change. But to-day, whether in English, languages, history or the sciences, too little consideration is often given to the past ten, thirty and a hundred years.

(2) Though the medieval scholarly tradition of book learning has already been much blended with practical manual activities, most school and some college laboratories could do with ten times the costly equipment, space and technician assistance, to give fully effective courses.

(3) The medieval scholarly tradition is mainly of 'pure' studies. It is suggested that in the later years of nearly everyone's education there could well be a higher proportion of applied aspects, both those of use to the general citizen and those which are specifically vocational. This could make higher education

both more interesting as well as a better preparation for later life.

(4) While the Renaissance, plus printing, greatly increased the store of written work available for study, the recent upsurge of science has increased our available scientific written knowledge and material equipments vastly more. Dr. D. J. Price, in *Discovery* of June 1956, gives evidence which suggests that our total scientific knowledge is roughly doubling every 10–15 years, and has been doing this for at least two centuries. The rate of increase is about a hundred-fold per century; and thus, since the schooldays of Newton, scientific knowledge seems to have increased by something like a million-fold. This has resulted in (*a*) the extended duration of science courses, and in (*b*) a further specialization in ever narrower sectors of our total knowledge. The special degree course has been built on top of the General, and university entrance is now preceded by a stiff two or three years in the sixth form in schools. But since lecturers and examiners find it very difficult to drop out older points of detail when new data are incorporated into a subject, there is still often an unhealthy overload of factual material to be memorized, as the Science Masters' Association has recently pointed out. One suspects that the amount of work necessary for graduation, a century ago, may have been little or no more than the work necessary for three General Certificate of Education (Advanced Level) science passes to-day—and perhaps the high-school student deserves more public credit for his achievement.

(5) The enormous increase of modern scientific knowledge has necessitated progressive specialization of courses. But one result is that, for each student, a greater proportion of the sectors of modern knowledge remains neglected. On the other hand, in an industrial democracy, it is most desirable that a large proportion of citizens should be properly equipped with a balanced outlook based on all branches of scientific and other knowledge; with "a broad outlook and a sense of spiritual and human values" (Circular 323). Thus a case can be made for devoting some 10 per cent of each week of sixth-form and college time to achieving this end.

The above five points arise partly from the rapidity of scientific advance and partly from the character of earlier scholastic education. They may be summed up as suggesting a further shift of emphasis: (1) from old to new; (2) from book learning to practical; (3) from pure to applied, including vocational; (4) from an encyclopædic to a more selective approach, and to still greater specialization of the main subject; but (5) towards developing, on the side, a balanced and integrated cultural background covering the whole range of modern knowledge.

Viewed in this kind of historical perspective, the real or potential virtues of the new courses for the Diploma in Technology are clearly apparent. The National Council for Technological Awards, which sponsors these courses, has given the teaching colleges considerable freedom in the design of syllabuses, and these are under constant review. Thus, while maintaining a serious academic coverage of principles, many older topics can be dropped out in favour of newer ones of contemporary relevance. The laboratory time of the eight terms at college is reinforced by four six-month periods of actual industrial employment; and the whole emphasis of the later years of the course is deliberately vocational and applied. In many places the importance of a selective rather than an encyclopædic approach is forcefully realized; while each course is at least as specialized as that for a special degree. In addition, there is an earnest groping towards a suitable development of non-vocational liberal studies, to occupy some 10 per cent of the time-table. The entrance requirement for a diploma in technology course is approximately the same as for a university, though National Certificates are recognized besides the General Certificate of Education. Some students are entered by industrial firms, while others come direct from school sixth forms. Most, though not all, diploma courses are conducted on the sandwich principle. Thus, in each of the four (or five) years, two terms at college are succeeded by six months in appropriate industrial employment; and it is expected that after the four years of scientifically and technologically up-to-date education and experience the average diploma holder will be at least as effective a member of his firm as the average graduate becomes after a further year or two of postgraduate training. Incidentally, the diploma qualification is now recognized as at least the equivalent of a degree by the Burnham Committee. Thus, it is also a route for the recruitment of younger school teachers, who will arrive at school with a much fuller understanding of contemporary life.

The annual intake of students to the diploma courses is at present 736, and is rising rapidly. 1957–58 is only the second year of normal enrolment, and in a few years the intake is likely to be several thousand. The courses are mainly conducted in the new colleges of advanced technology, and where there is a research tradition. The students attending come from all parts of the country. By last autumn the number of subjects for which courses had received the provisional approval of the National Council, at the different centres, was as follows:

Battersea, London	7 subjects
Birmingham	7
Northampton, London	7
Brunel, London	6
Chelsea, London	3
Northern, London	3
Woolwich, London	3
Borough, London	2
Loughborough	2
Cardiff	1
Kingston, Surrey	1
Wolverhampton	1

In a few cases these courses have not yet commenced, but on the other hand in some colleges, especially Battersea College, the courses are run in duplicate—sandwich plus full-time.

In conclusion, it may be mentioned that the courses running last spring, numbering forty in all, had the following subject distribution:

Mechanical and production engineering	9 courses
Electrical engineering	8
Applied chemistry, etc.	7
Physics	5
Metallurgy	3
Aeronautical engineering	2
Chemical engineering	2
Mathematics	2
Applied biology	1
Civil engineering	1

The engineering and other studies which have developed from the basic work done by the old flint knappers, bronze smiths and millwrights are well represented; but there is already one course, at Brunel College, dealing with the industrial aspects of living organisms.

OPENCAST MINING IN BRITAIN

THE Opencast Coal Bill, which received a second reading in the House of Lords on June 26, repeals the Defence Regulations under which opencast coal operations are now carried on. In moving the second reading, the Minister of Power, Lord Mills, said that the Bill was the last and largest step in replacing by statutory provisions the Defence Regulations relating to land. The Water Bill and the Land Powers (Defence) Bill had been other measures to that end. Lord Mills said that opencast coal working on a substantial scale began in 1942 to help relieve the acute shortage of coal that had then developed, and since then the opencast sites had produced 160 million tons of coal from slightly less than 110,000 acres, mostly agricultural land, or about 0·25 per cent of our total agricultural land. The opencast output was now about 14 million tons a year, about a quarter of which was large coal, and would fall in two or three years to about 4 million tons unless new sites came into production. To avoid a resumption of imports and replacing restrictions on supplies of house coal we must maintain a substantial level of opencast output for some time and would probably need some opencast coal for the next ten years. Lord Mills assured the House that he would give very close attention to the National Coal Board's plans for opencast coal output with the view of maintaining adequate supplies of coal while doing the minimum damage to agriculture and amenity. In recent months we had been able to defer indefinitely the working of several sites and he hoped the improved position would enable us to be a little more selective.

Lord Mills said that when the new Bill came into operation the National Coal Board intended, whenever possible, to obtain the land or rights in land which they needed for opencast working by agreement, and he gave as one reason for the new legislation the high standard of agricultural restoration after opencast coal working which we had developed. To ensure the maintenance of that high standard we must make special arrangements for close Ministerial control of opencast coal production. He stated categorically that it was the Government's intention at least to maintain present standards of restoration, and, in particular, to require the Board, in the national interest, to restore all agricultural land to the general standard laid down in a code of restoration which was adopted in 1951 and is now being improved as a result of recent discussions between his Department and the National Coal Board and the agricultural organizations. This code provides for five years special treatment of restored agricultural land, and under the Bill the Agricultural Departments would continue to carry out this treatment for the Board, while the Forestry Commission would act similarly for woodland.

In explaining the compulsory powers under the Bill, Lord Mills said that, by Clauses 4 and 6, the Board was empowered to acquire the rights needed to hold, for up to ten years, land at present held under requisition from opencast coal disposal points and stocking grounds. Clause 9 provided that no compulsory rights order could be made against an occupied dwelling house, its garden and certain other land held with it, while every compulsory rights order would be subject to confirmation by the Minister of Power under a procedure which ensured a right to object and to have objection heard. In replying on the debate, Lord Mills said that he was convinced that it would have been wrong to suggest any shorter period than ten years for the operation of the Bill. He was not entirely satisfied that the Bill adequately covered the possible effect of opencast coal working on water supplies, but the Government did not intend that the powers it conferred should enable the National Coal Board to over-ride the Water Act, 1945, or bye-laws made under that Act.

SYNOPTIC CLIMATOLOGY

SYNOPTIC climatology provides mean values and other statistical parameters of the temperature, cloudiness, precipitation and so on, which are related to the type of air mass and the large-scale distribution of air pressure. It differs in this way from the older type of climatology based more or less exclusively on time of year, which lumped all the atmospheric circulation types together. Types of circulation outside the tropics are by no means closely related to season, however, though some are more frequent in one season than in another. Moreover, the weather in a given type can differ greatly from one season to another, as is evident from the difference between winter and summer in the effect on temperature over western Europe of a persistent high-pressure area over Scandinavia. Such an area has easterly winds to the south of it.

Knowledge of the weather associated with a given type is essential to the weather forecaster, who works by first predicting the pressure distribution and then the associated weather. These two stages are more clearly marked in the modern numerical method of forecasting based on the approximate solution of the equations of motion of the atmosphere by replacing the differential coefficients by finite differences than in the older and more subjective method.

A notable contribution to the synoptic climatology of the British Isles was Dr. Belasco's "Characteristics of Air Masses over the British Isles" (Meteorological Office Geophysical Memoir, No. 87 ; 1952).

Now the Weather Service of the Federal German Republic has published an even more elaborate synoptic climatological study in Dr. K. Bürger's work, "Zur Klimatologie der Grosswetterlagen, ein witterungsklimatologischer Beitrag"*. This is a truly monumental record of the synoptic climatology of western Germany (including Berlin). *Witterung*, a useful word for which there is no single equivalent in English, implies "the constant element in a sequence of weather situations over several days", and *Gross-*

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* Berichte des Deutschen Wetterdienstes. Nr. 45 (Band 6): Zur Klimatologie der Grosswetterlagen, ein witterungsklimatologischer Beitrag. Von Kurt Bürger. 79 s. mit 2 Abbildungen und 36 Tabellen im Text, sowie 13 Zahlentafeln und 8 Bildtafeln im Anhang. (Offenbach/M.: Deutschen Wetterdienstes, 1958.) 46.60 D.M.

wetterlage means "the main constant circulation and main pressure distribution over the area studied during the period for which the weather type (*Witterung*) persists".

Bürger's work is based on the analysis by punched cards of the observations of temperature, cloud and precipitation at Berlin, Bremen, Karlsruhe and Munich over the period 1890–1954 (omitting 1945). Twenty-eight types of circulation (*Grosswetterlage*) are distinguished, taken for the period to 1952 from Hess and Brezowsky's "Katalog der Grosswetterlagen Europas" (Berichte des Deutschen Wetterdienstes U.S.-Zone, Nr. 33 ; 1952).

The statistics of the types and of the elements considered in relation to the types set out in numerous tables and diagrams with seventy-eight large pages of commentary include the monthly means for each type, with deviations from the means, and much additional information—such as the types which bring the earliest and last frosts and snowfalls of the year.

As an example of the seasonal differences in the weather associated with circulation types it is shown in one of the tables that while southerly and south-easterly winds associated with an anticyclone are nearly the coldest at Berlin in winter, with a mean temperature 5° C. below the seasonal mean, by May they have become warmest, with a mean temperature 3·1° C. above the seasonal mean. There are naturally differences in the effect of different circulation types at the four stations, notably between Bremen and Munich.

The effect of continentality is clearly shown in the dependence of the standard deviations on place and type. The frequency of temperatures and precipitation between specified limits and occasions of extreme values are listed and referred to their circulation type.

There is no discussion of upper air conditions, but perhaps they will be similarly dealt with later.

EFFECT OF COLCHICINE ON THE UTILIZATION OF LABELLED THYMIDINE DURING CHROMOSOMAL REPRODUCTION

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It has been accepted that labelled thymidine is incorporated only into deoxyribonucleic acid[1]. Taylor *et al.*[2] used thymidine labelled with tritium to provide information on the mode of chromosome replication, and colchicine was employed to assist in clarifying the way in which the tracer was inherited by the daughter chromosomes in the meristematic cells of roots of *Vicia faba*. Autoradiographs over chromosomes were obtained by the stripping film technique in squash preparations. Taylor and his collaborators grew seedlings in nutrient solution containing thymidine-^{3}H for 8 hr., then transferred the plants to nutrient solution containing a concentration of 0·05 per cent colchicine, and fixed root tips 18 and 42 hr. after the start of labelling. Colchicine, by inhibiting spindle formation, allowed them to distinguish with certainty the first (X_1) and second (X_2) mitosis after labelling. *C*-metaphases with the normal complement of 12 chromosomes would be expected in the roots fixed at 18 hr. and a high proportion of *C*-metaphases with 24 chromosomes in those fixed after 42 hr.

In *C*-metaphases of X_1 cells they report that both chromatids in each of the 12 chromosomes were equally labelled along their length, while in *C*-metaphases of X_2 cells usually only one of the chromatids in each of the 24 chromosomes was labelled along its length. A few X_3 cells (48 chromosomes) were found in roots fixed after 42 hr., in which about half the chromosomes were unlabelled, the remainder being labelled in one chromatid. In X_2 and X_3 cells a few chromatids were labelled along only part of their length, but in these instances the sister chromatids were labelled in complementary segments. This exchange was attributed to somatic crossing-over.

These findings were interpreted as showing that the deoxyribonucleic acid is synthesized as an intact unit, and that reproduction in chromosomes which behave as if they consist essentially of one molecule is by means of a template based on a double-helix model, as envisaged by Watson and Crick[3]. In this system each chromatid after replication would consist of two strands, one with 'old' and one with 'new'

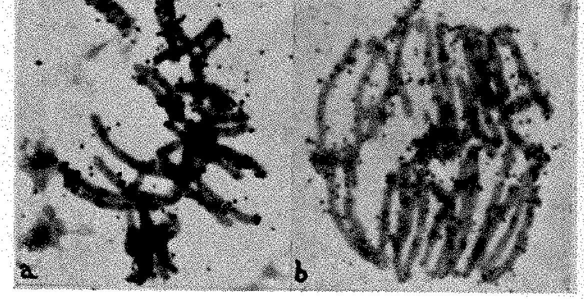

Fig. 1. Autoradiograph of X_2 metaphase (*a*) and X_2 anaphase (*b*) from roots of *Vicia faba* grown for 12 hr. in tap-water containing thymidine-^{3}H followed by 36 hr. in pure tap-water. Squash preparations stained in toluidine blue after autoradiography. Note in metaphase labelling in both chromatids of *s*-chromosomes at top left and right, unequal labelling in others and at bottom left labelling in discrete homologous regions of both chromatids (× 1,300)

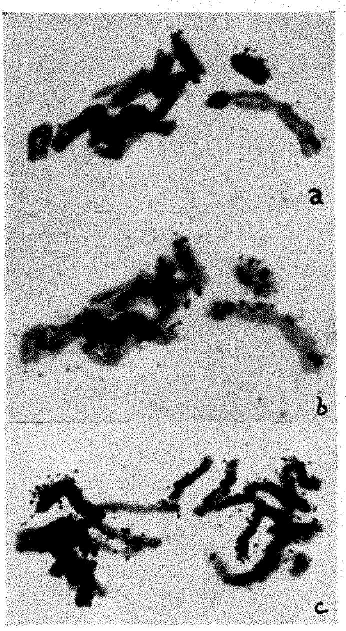

Fig. 2. X_1 *C*-metaphase and X_1 *C*-anaphase (*c*) from roots of *V. faba* grown for 1 hr. in 0·05 per cent colchicine prior to treatment for 8 hr. with colchicine and thymidine-^{3}H, followed by 0·05 per cent colchicine in tap-water for 12 hr. Squash preparations stained in Feulgen before autoradiography. (*a*) Focused on the chromosomes; (*b*) focused on photographic grains; (*c*) *C*-anaphase. In the metaphase an *M*- and an *S*-chromosome show labelling in one chromatid only; one chromatid of an *S*-chromosome is unlabelled in the *C*-anaphase. (× 1,300)

deoxyribonucleic acid, which are in turn separated during synthesis for the X_2 mitosis.

This interpretation, however, is dependent on the supposition that colchicine would in no way influence the process of replication at the X_2 interphase. In an initial experiment we therefore dispensed with its use. Seedlings of *V. faba*, with lateral roots, were grown at a temperature of 20° C. in separate containers in tap-water to which thymidine-^{3}H (supplied by Messrs. Schwartz, Inc., New York) was added. Each plant received 25 µc. and the plants were transferred to pure tap-water after 12 hr. Roots were fixed after, 4, 6, 12, 24 and 48 hr. and autoradiographs of squash preparations were prepared by the stripping film technique. The 4-, 6- and 12-hr. samples were considered necessary for comparison with earlier data obtained[4] in *V. faba* with phosphorus-32.

Very few mitotic figures were labelled in the roots fixed after 12 hr., and then only weakly. In roots fixed after both 24 and 48 hr. the autoradiographs were found to be labelled along the length of both chromatids over most metaphase chromosomes (Fig. 1*a*), and also along both daughter chromatids at anaphase (Fig. 1*b*). In the sample fixed after 48 hr., however, some chromosomes with singly labelled chromatids occurred in 12 per cent of the metaphases.

It was necessary to have criteria for distinguishing the X_1 and X_2 mitoses after labelling. The proportion of interphase nuclei labelled at 4, 24 and 48 hr. is only 20–25 per cent and it can be concluded that the labelled compound is used up after approximately one-quarter of the mitotic cycle (6 hr.). This excludes the possibility of additional labelling during the second period of synthesis of deoxyribonucleic acid and on average the nuclei at the X_2 mitosis should contain half the tracer found at X_1. After 48 hr. 16 per cent of the metaphases were heavily labelled and can be regarded as X_1 mitoses; a similar proportion of X_1 and X_2 metaphases were found after 48 hr. in a later experiment in which colchicine was used. The average duration of the mitotic cycle in the root meristem of *V. faba* has been found by various methods to be about 24 hr.[4,5], and very few X_1 mitoses would be expected after 48 hr. Synthesis of deoxyribonucleic acid lasts for 6–8 hr. and the division 1 hr. after an intervening period of about 8 hr.[4]. It can therefore be expected that no more than one-fifth of the labelled metaphases at 48 hr. were X_1.

It was concluded that the results obtained by Taylor and his collaborators were due largely to the extended treatment with colchicine and especially to the fact that only the X_2 period of chromosome replication took place in the presence of this agent. It seemed possible that chromosomes with singly labelled chromatids might be obtained at the X_1 mitosis by pre-treatment of the roots with colchicine.

Seedlings grown as described before were transferred to tap-water containing a concentration of 0·05 per cent colchicine to which thymidine-^{3}H was

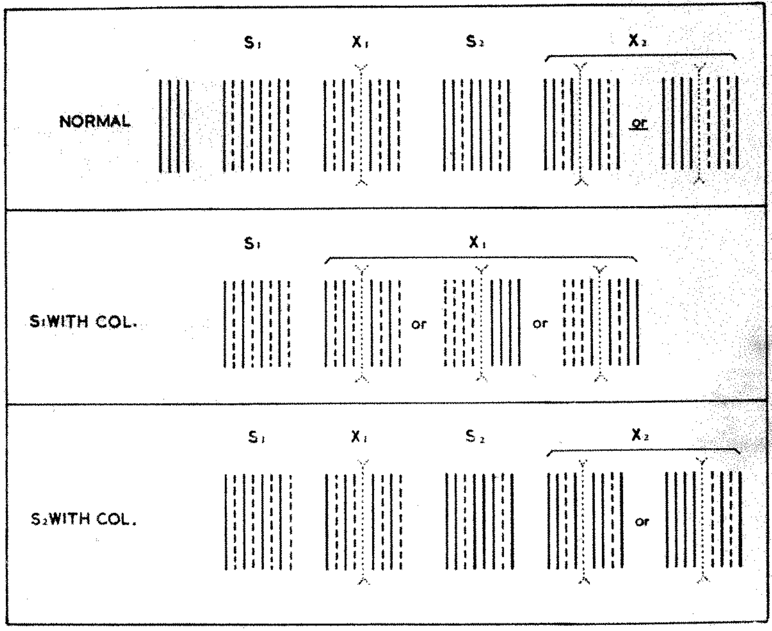

Fig. 3. Scheme of chromosome reproduction assuming four strands before replication. It is assumed that labelled thymidine is available at the first period of synthesis (S_1) but not during the second (S_2) and that colchicine (*col*) influences the segregation of new and old strands, possibly by an effect on the centromere. In the absence of colchicine the alternative (*or*) at X_2 is considered a rare possibility, but this might perhaps explain the results of Plaut and Mazia (ref. 7) with thymidine-^{14}C in *Crepis capillaris* if it is assumed that the duration of the mitotic cycle is shorter than in *Vicia* or that the number of strands is different. Strands figured as broken lines are those containing thymidine-^{3}H

added 1 hr. later. This was replaced after 8 hr. by fresh tap-water with colchicine, and roots were fixed after 20 and 24 hr.

In both samples the *C*-metaphases contained some chromosomes labelled along the length of both chromatids and some only along the length of one (Fig. 2*a* and *b*). So far as could be seen, very few *C*-metaphases showed all the 12 chromosomes with labelling in both chromatids. Furthermore, closely similar results to these were obtained in X_2 metaphases when we repeated the experiment of Taylor and his collaborators. Complete analysis in tetraploid cells was more difficult, but many *C*-metaphases clearly contained a few chromosomes labelled along the length of both chromatids in addition to those labelled only in one. These observations conflict with those of Taylor *et al.*, and it is justifiable to assume that colchicine can markedly alter the results obtained.

In the presence of a labelled precursor, self-reproduction of deoxyribonucleic acid based on the Watson and Crick model should result in labelled molecules and therefore should never lead to one chromatid of a chromosome being unlabelled at the X_1 mitosis. As a working hypothesis, for which cytological evidence is available[6], it is worth while considering that the chromosome may be multiple-stranded at the time of reproduction. If it is assumed that each chromosome consists of four strands before duplication (Fig. 3) and that each chromatid after replication usually consists of two new and two old strands, then the appearance of equally labelled chromatids at both the X_1 and X_2 mitosis would be expected. If it is further assumed that colchicine could influence the segregation of new and old strands, and hence the distribution of new and old deoxyribonucleic acid, then a situation as envisaged in Fig. 3 could arise. This working hypothesis can be checked experimentally with thymidine-^{3}H and possibly most simply in the absence of colchicine. If this is correct, for *V. faba* at least, grand-daughter cells (X_2) from the labelled X_1 should contain chromosomes with one labelled and one unlabelled chromatid.

Some other facts that are likely to affect interpretation in further studies were noticed in our experiments. Occasionally, both in X_1 and X_2 metaphases, labelled and unlabelled chromosomes occurred together in the same cell and twice an *M*-chromosome was found labelled in only one arm. This kind of disparate labelling appears to be confined to weakly labelled cells and suggests that not all the chromosomes in a cell are replicated exactly at the same time. It would become apparent in cells which had undergone synthesis when the store of labelled compound was near depletion, or where the chromosomes had nearly completed reproduction when the label became available. Also, at interphase, small parts of labelled nuclei may show absence of autoradiographs. In many cells this is clearly associated with heterochromatic regions and suggests that these may be replicated at a different time from the euchromatic portions of the chromosomes. Occasionally, however, the interphase nuclei show a similar absence in other chromosome parts. Therefore, the possibility cannot be ignored that sometimes in some parts of the chromosomes the labelled thymidine may perhaps be replaced after synthesis by unlabelled thymidine. No instance of somatic crossing-over was observed, but this possibility must also be considered.

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CONDITIONAL ANTI-MUTAGENESIS IN *DROSOPHILA MELANOGASTER*

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IN a previous communication[1], I have reported that adenine produces a significant depression of the mutagenic activity of formaldehyde when both compounds are simultaneously present in the food of developing *Drosophila melanogaster* larvæ. The experiment leading to this observation was based on the working hypothesis that formaldehyde is effective as a mutagen by the larval feeding method, by competing with the normal (formic acid) metabolite in purine biosynthesis. The addition to the test system of preformed purine, in this case as adenine, is believed to decrease the mutagenic activity of formaldehyde by 'by-passing' the biosynthetic sequence through which formaldehyde is assumed to act. The present communication describes a further observation on the anti-mutagenic activity of adenine towards formaldehyde, consistent with this hypothesis.

The culture medium and methods used are as previously described[1]; Distillers' Co., Ltd., yeast was the yeast employed in the treatment medium.

Curves *a* and *b*, Fig. 1 (see Table 1), illustrate respectively the first and second brood response of the percentage of sex-linked recessive lethal mutations to the concentration of formaldehyde in the treatment medium. The first brood response shows an increase with increasing formaldehyde concentrations, becoming asymptotic at approximately $3 \cdot 0 \times 10^{-2}$ *M*. From the hypothesis, it might therefore be assumed that the response of the first brood to increasing concentrations of formaldehyde (Fig. 1, curve *a*) represents a measure of the extent to which formaldehyde interferes in purine synthesis, the response becoming asymptotic when formaldehyde is saturating the system. The second brood response increases up to approximately $2 \cdot 0 \times 10^{-2}$ *M* form-

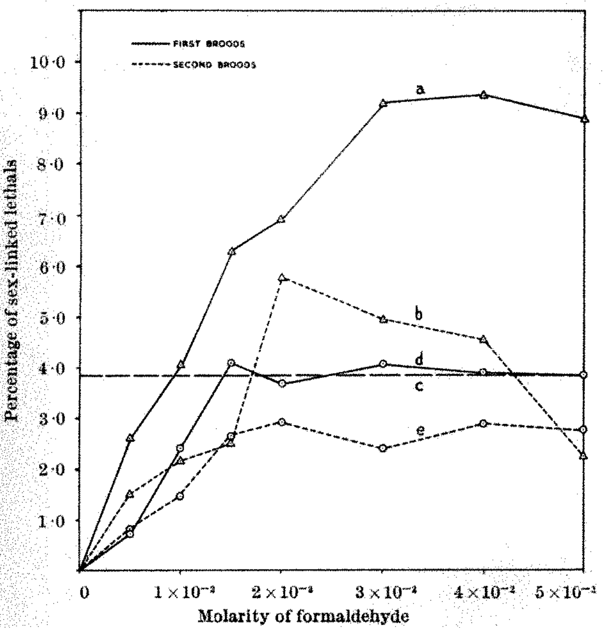

Fig. 1. Anti-mutagenic effect of adenine towards formaldehyde at different concentrations of formaldehyde. Curves *a* and *b* represent respectively the dose–mutagenic response for formaldehyde of the first and second brood; *d* and *e* their response in the presence of the antimutagen, adenine

aldehyde, but falls off at higher concentrations; this latter effect is thought to be due to the increased toxicity of the treatment at the higher concentrations. For the purpose of discussion, it is convenient to consider only the first brood response, owing to the irregularity of response in the second brood.

In the case previously reported[1], the addition of 0·09 per cent adenine ($6 \cdot 6 \times 10^{-3}$ *M*) to the test medium reduced the mutagenic activity of formaldehyde from 9·72 per cent to 3·37 per cent sex-linked lethals in the first brood, where 0·4 per cent (4×10^{-2} *M*) formaldehyde was used as the test concentration. Thus one might conclude, *ex hypothesi*, that the actual decrease in the mutagenic effectiveness of formaldehyde is due to a corresponding decrease in purine synthesis, produced by the addition of adenine; this decrease is represented by the difference in value recorded for $4 \cdot 0 \times 10^{-2}$ *M* formaldehyde on curve *a* from that indicated by line *c* (Fig. 1). A reduction of purine synthesis to the level indicated by line *c* is therefore anticipated when this amount of adenine is added to the test medium.

Accordingly, if the formaldehyde concentration is varied by attenuated dosage over the range recorded in the dose-effect curve, the concentration of adenine itself being kept constant at $6 \cdot 6 \times 10^{-3}$ *M*, a concentration of formaldehyde will be reached (which one might take tentatively as approximately $1 \cdot 0 \times 10^{-2}$ *M*, see Fig. 1), at which adenine should show no anti-mutagenic effect; this is because the amount of formaldehyde present is at a level with, or less than, that to which purine synthesis is reduced. Thus, one might expect that the anti-mutagenic effectiveness of adenine towards formaldehyde will decrease as the concentration of formaldehyde decreases, until the point is reached at which it might be allowed that the anti-mutagenic effect disappears; at this latter point, and over the sensitive range of formaldehyde concentrations, the mutagenic activity of formaldehyde should therefore be reduced to the level delineated by line *c* (Fig. 1). These conjectures form the basis for the experiments reported here.

In anticipation of the objection that formaldehyde might be removed from the treatment medium by simple chemical combination with adenine, a test was carried out *in vitro* for detection of the extent to which formaldehyde and adenine combine chemically, using the methone method for gravimetric estimation of formaldehyde[2]. At concentrations of $4 \cdot 0 \times 10^{-2}$ *M* formaldehyde and $6 \cdot 6 \times 10^{-3}$ *M* adenine, a reduction in formaldehyde concentration to $3 \cdot 5 \times 10^{-2}$ *M* was detected, which as can be seen by reference to the dose-effect curve (Fig. 1, curve *a*) would have no appreciable effect on the percentage of lethals produced. Indeed, if the anti-mutagenic activity of adenine was one simply involving removal of formaldehyde from the treatment medium by its chemical combination with adenine, the anti-mutagenic activity would be expected to increase with decreasing formaldehyde concentration, since the removal of formaldehyde would be more effective at the lower concentrations. It follows from the working hypothesis that the chemical removal of formaldehyde by adenine is only a consideration at concentrations of formaldehyde actually below that to which purine synthesis is reduced, since at higher concentrations the actual concentration of formaldehyde would be greater than its effective concentration.

Thus Table 2 formulates the results obtained from testing the anti-mutagenic activity of adenine at different concentrations of formaldehyde; these results are illustrated graphically for first and second broods by curves *d* and *e*, respectively (Fig. 1). In the first brood, the mutagenic effectiveness of form-

Table 1. THE DOSE-EFFECT RESPONSE FOR FORMALDEHYDE

Molarity of formaldehyde	$0 \cdot 5 \times 10^{-2}$	$1 \cdot 0 \times 10^{-2}$	$1 \cdot 5 \times 10^{-2}$	$2 \cdot 0 \times 10^{-2}$	$3 \cdot 0 \times 10^{-2}$	$4 \cdot 0 \times 10^{-2}$	$5 \cdot 0 \times 10^{-2}$
First broods							
n Chrom.	415	1,009	352	1,519	695	6,052	451
n Leth.	11	41	23	105	64	566	40
Per cent leth.	2·65	4·06	6·53	6·91	9·21	9·35	8·87
Second broods							
n Chrom.	330	1,312	440	1,451	910	4,714	493
n Leth.	5	28	11	84	45	214	11
Per cent leth.	1·52	2·13	2·50	5·79	4·95	4·54	2·23
Third broods							
n Chrom.		268			265		
n Leth.		2			7		
Per cent leth.		0·74			2·64		

n Chrom. = total number of chromosomes examined.
n Leth. = number of lethal chromosomes.
Per cent leth. = percentage of sex-linked recessive lethal mutations.

Table 2. The Anti-mutagenic Effect of Adenine towards Formaldehyde at Different Concentrations of Formaldehyde

Molarity of adenine	$6 \cdot 6 \times 10^{-3}$						
Molarity of formaldehyde	$0 \cdot 5 \times 10^{-2}$	$1 \cdot 0 \times 10^{-2}$	$1 \cdot 5 \times 10^{-2}$	$2 \cdot 0 \times 10^{-2}$	$3 \cdot 0 \times 10^{-2}$	$4 \cdot 0 \times 10^{-2}$	$5 \cdot 0 \times 10^{-2}$
First broods							
n Chrom.	676	1,461	1,363	1,231	1,027	869	909
n Leth.	5	35	57	46	43	34	35
Per cent leth.	0·74	2·39	4·18	3·74	4·18	3·91	3·85
Second broods							
n Chrom.	243	756	528	546	251	382	795
n Leth.	2	11	14	16	6	11	22
Per cent leth.	0·82	1·45	2·65	2·93	2·39	2·88	2·77
Third broods							
n Chrom.		371			263		
n Leth.		0			4		
Per cent leth.		0·00			1·52		

n Chrom. = total number of chromosomes examined.
n Leth. = number of lethal chromosomes.
Per cent leth. = percentage of sex-linked recessive lethal mutations.

aldehyde for all concentrations above approximately $1 \cdot 5 \times 10^{-2}$ *M* formaldehyde is seen to be depressed down to the level postulated. The second brood follows essentially the same pattern, but is depressed lower than in the first brood; this may be because the normal brood gradients for the mutagenic activity of formaldehyde (curves *a* and *b*) involve different levels of purine synthesis, so that, in effect, adenine is able to depress purine synthesis more effectively in the second brood. At concentrations of formaldehyde below $1 \cdot 5 \times 10^{-2}$ *M*, the anti-mutagenic effect of adenine in both broods is much less apparent, and here may be accounted for simply by removal of formaldehyde by chemical combination with adenine. Third broods were sampled at $1 \cdot 0 \times 10^{-2}$ *M* and $3 \cdot 0 \times 10^{-2}$ *M* formaldehyde. Usually, the mutation-rate has returned to the spontaneous level by the third brood, but as can be seen from Tables 1 and 2, some mutagenic activity is still detectable. A slight anti-mutagenic trend can also be observed here.

As previously reported[1], the anti-mutagenic activity of adenine towards formaldehyde is conditional on the strain (and concentration) of yeast employed in the culture medium. The present communication describes a further case of conditional anti-mutagenesis; namely, the concentration of the mutagen at which anti-mutagenic activity is tested.

I wish to acknowledge financial support from the Medical Research Council, under the auspices of which this work was carried out.

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FRACTIONATION OF CELL SUSPENSIONS IN AN ELECTROMAGNETIC FORCE FIELD

By Prof. ALEXANDER KOLIN and RAYMOND T. KADO
Department of Biophysics, University of California, Los Angeles

THE effectiveness of centrifugation as a method of fractionation of aqueous suspensions of cells and of cell debris is limited by the fact that the densities of these biological materials differ but little from each other and from the density of the suspension fluid. The effective electrical conductivities of cells, on the other hand, vary widely, sometimes by two or three orders of magnitude. A method of fractionation based on differences in electrical conductivites, rather than in densities, of suspended particles would therefore be of interest. The possibility of developing such a method is suggested by an effect recently described by one of us[1]. It has been shown that a spherical particle of conductivity σ' suspended in a fluid of conductivity σ'' experiences a force when a homogeneous current is passed through the suspension across which a homogeneous magnetic field is maintained preferably at right angles to the current. The force is perpendicular to the magnetic field and the current and is given by the expression:

$$\mathrm{F} = \frac{3}{2} V \left(\frac{\sigma'' - \sigma'}{2\sigma'' + \sigma'} \right) [\mathbf{J} \times \mathbf{B}] \qquad (1)$$

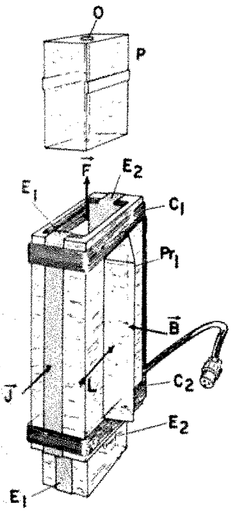
where V is the volume of the sphere, **J** the current density and **B** the magnetic flux density[2]. This force is seen to vanish for $\sigma'' = \sigma'$ and to reverse direction for $\sigma' > \sigma''$.

The velocity of a spherical particle of radius R in a fluid of viscosity η is given by the expression:

$$v = \frac{R^2}{3\eta} \left(\frac{\sigma'' - \sigma'}{2\sigma'' + \sigma'} \right) [\mathbf{J} \times \mathbf{B}] \qquad (2)$$

This equation suggests the possibility of separating particles on the basis of differences in R and in σ'.

To obtain unidirectional migration, it is not necessary to use unidirectional currents and constant magnetic fields. This result may be also obtained by using alternating magnetic fields and currents in



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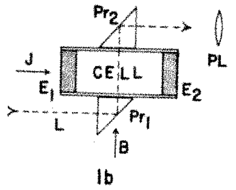

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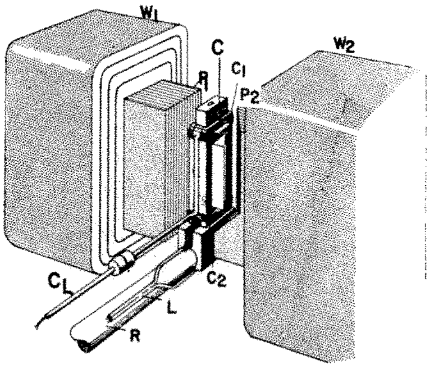

1c

Fig. 1*a*. Migration cell: E_1, E_2, electrodes; Pr_1, prism; C_1, C_2, coils; L, illuminating light beam; J, current density vector; B, magnetic field vector; F, force vector; P, plug; O, overflow channel

Fig. 1*b*. Light path L (indicated by broken line): E_1, E_2, electrodes; Pr_1 and Pr_2, prisms; J, current density vector; B, magnetic field vector; PL, projection lens

Fig. 1*c*. Migration cell in the magnetic field: W_1 and W_2, magnet coils; P_1 and P_2, pole pieces (P_2 is depicted cut-away to show the cell); C, migration cell; C_1 and C_2, adjustment coils; R, support rod; L, electrode lead wires; CL, lead wires for coils C_1, C_2

phase. The use of alternating currents greatly simplifies the design of the migration cell which is shown in Fig. 1*a*. The current **J** is passed between the parallel metal electrodes E_1, E_2. The other two parallel walls of the migration channel of the cell are made of 'Lucite'. Light enters the migration channel after reflexion inside the prism Pr_1. It traverses the cell parallel to the magnetic field vector B and hits a prism Pr_2 (shown in Fig. 1*b*) mounted parallel to Pr_1 on the opposite side of the cell. The 45 deg. surface of Pr_2 is oriented so as to reflect the light parallel to and in the same direction as L_1. A projection lens PL located beyond Pr_2 (Fig. 1*b*) forms an image of the interior of the migration channel on a distant screen. Fig. 1*c* shows the cell placed between the pole pieces P_1 and P_2 of the magnet. The plug P, shown above the cell in Fig. 1*a*, is inserted into the migration channel after the cell is filled. This plug is provided with a narrow channel O for escape of surplus liquid. The vector **F** indicates the direction of the force exerted upon the suspended particles for $\sigma' > \sigma''$ and, hence, the direction of migration. C_1 and C_2 (Fig. 1*a*) are coils wound about the migration cell. They facilitate adjustment of the cell at right angles to the magnetic field. When the cell is properly oriented the electromotive force induced in the coils C_1 and C_2 vanishes.

Two experimental difficulties must be eliminated before successful fractionation of suspensions can be accomplished: (1) the thermal convection caused by a horizontal temperature gradient established by passage of a current through the cell must be eliminated; and (2) the electromagnetic convection[3] caused by non-uniformities in the magnetic field and/or in the current density distribution in the fluid column must be suppressed. The horizontal temperature gradient is associated with a horizontal density gradient which upsets the gravitational equilibrium in the fluid column. The effect produced by a non-uniformity in the magnitude of $[\mathbf{J} \times \mathbf{B}]$ at right angles to the **F**-axis is analogous, since the force density $\mathbf{f} = [\mathbf{J} \times \mathbf{B}]$ is the counterpart of the weight density in the case of gravitational equilibrium.

Both types of convection can be effectively inhibited by establishing a steep density gradient in the migration column. This device has been previously used successfully for suppression of thermal convection in electrophoresis[4]. An adequate density gradient can be produced by filling the lower half of the cell with a 5 per cent solution of sodium chloride containing 46 gm. of sucrose per 100 ml. of solution and the upper half with 1·3 per cent sodium chloride solution. The density gradient is established by stirring the liquid column.

A droplet of the suspension to be fractionated is now injected into the density gradient. It settles at the density-level corresponding to its own density. Fluid is then withdrawn from this level by micropipette to create a density discontinuity. A small amount of the suspension (the density of which is adjusted to the value of the density of the withdrawn fluid) is now carefully injected at the level of the density jump so as to create a thin sharp zone. The conductivity of the suspension is adjusted approximately to the value of the conductivity of the density

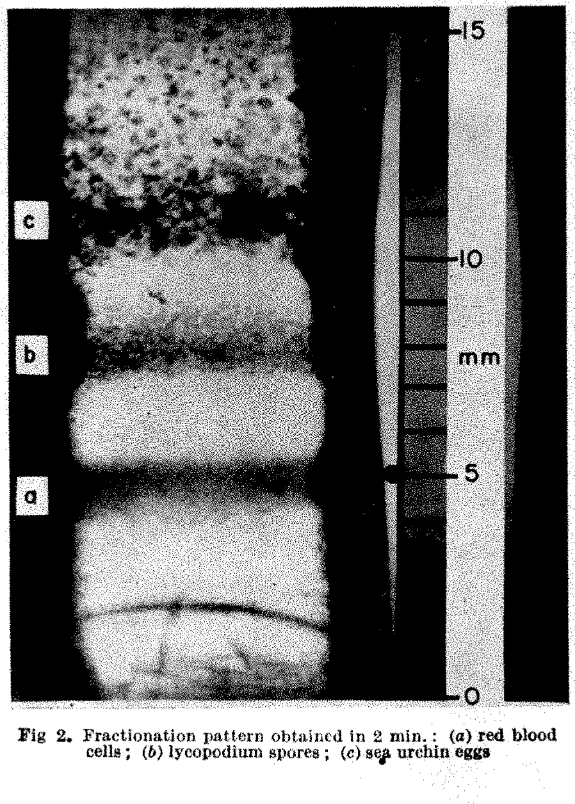

Fig 2. Fractionation pattern obtained in 2 min.: (*a*) red blood cells; (*b*) lycopodium spores; (*c*) sea urchin eggs

gradient column. When the magnetic field and current are turned on, the particles suspended in the initial zone begin to migrate with different speeds and the zone finally splits into separate zones containing the different components of the mixture.

Fig. 2 shows a fractionation which was accomplished within approximately 2 min. The mixed suspension contained (*a*) red blood cells ($R \simeq 4\,\mu$), (*b*) lycopodium spores ($R \simeq 15\,\mu$) and (*c*) sea urchin eggs ($R \simeq 60\,\mu$). The thin curved black line below the *a*-zone depicts a steep refractive index gradient formed by convection near the bottom of the cell. The magnetic field $\mathbf{B} \simeq 6{,}000$ gauss (root mean square value) and the current density $\mathbf{J} \simeq 100$ m.amp./cm.^{2}. The temperature rise in the liquid during this time amounted to $\Delta t \simeq 5°$ C. The frequency of the field used was 60 c./s.

It has been shown that this effect can also be produced in a cylindrically symmetrical configuration[5]. In this case the magnetic field of a straight wire is used in combination with an electric current parallel to the wire. The force field thus generated is centripetal or centrifugal, depending on the phase relation between **B** and **J**. This arrangement offers the prospect of centrifugation without rotational motion.

This work has been supported by grants from the Office of Naval Research and from the California Institute for Cancer Research.

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SIGNIFICANCE OF INDUCED *IN VIVO* SYNTHESIS OF DIPHOSPHOPYRIDINE NUCLEOTIDE

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THE observation that the injection of nicotinamide into mice can produce large increases in the amount of diphosphopyridine nucleotide in the liver[1] has facilitated the *in vivo* study of many interesting biochemical problems. A description of some of the results which have been obtained, and a discussion of possible further applications of this system, are presented here.

Nature of Diphosphopyridine Nucleotide Synthesis

Extent of synthesis. The increase in diphosphopyridine nucleotide following the injection of nicotinamide is temporary, and is roughly proportional to the dosage of nicotinamide up to a level of 500 mgm. per kgm. With this dose the diphosphopyridine nucleotide content of mouse liver reaches a level of 8 – 10 times the base value of 400 – 500 μgm. per gm. wet weight at about 10 hr., then returns to normal at the end of 24 hr. Two- to three-fold increases in the diphosphopyridine nucleotide content of other tissues such as kidney, spleen and tumour also occur. Oxidized diphosphopyridine nucleotide accounts for almost all the increase in pyridine nucleotides following the administration of nicotinamide. Attempts to show an accumulation of diphosphopyridine nucleotide by incubating liver slices or fortified homogenates with nicotinamide have been unsuccessful.

Pyridine precursors. The initial observation of a marked increase in diphosphopyridine nucleotide content of mouse liver was made after the administration of the nicotinamide antagonist 3-acetylpyridine[2]. When similar results were obtained with nicotinamide it became clear that acetylpyridine was being converted to nicotinamide *in vivo*. The conversion of an anti-metabolite to a metabolite in this instance can be considered as a type of detoxification mechanism.

A number of other pyridine derivatives, such as β-picoline, can also act as precursors of diphosphopyridine nucleotide in the whole animal[3]. The effectiveness of these compounds in producing synthesis of diphosphopyridine nucleotide can be correlated with their ability to replace nicotinamide in the diet of the duckling[4]. Of special interest is the observation that nicotinic acid is much less effective than nicotinamide as a precursor, and can even inhibit the conversion of nicotinamide to diphosphopyridine nucleotide[3].

Effect of diphosphopyridine nucleotide synthesis on the chemical composition of mouse liver. The biosynthesis of diphosphopyridine nucleotide stimulated by nicotinamide is reflected as an increase in the

Table 1. CHANGE IN SOME ACID-SOLUBLE CONSTITUENTS OF MOUSE LIVER FOLLOWING THE ADMINISTRATION OF NICOTINAMIDE

	μmoles per gm. wet weight	
	Control	Nicotinamide injected
Diphosphopyridine nucleotide	0·79	5·74
Total nicotinamide	0·73	5·99
Adenine	3·8	8·4
Ribose	12·9	20·4
Total phosphate	48·2	59·4

Analyses were carried out on a 5 per cent trichloracetic acid extract prepared from the livers of mice killed 8 hr. after the administration of 500 mgm. per kgm. of nicotinamide. Controls were injected with saline. Adenine was determined by the colorimetric method of Woodhouse (ref. 5), which gave results in good agreement with values calculated from the increase in optical density at 260 mμ (ref. 1). Total nicotinamide was determined by the Holman method (ref. 6) after boiling at 100° for 30 min. (*p*H 7·8). The values represent the pooled samples of four mice in each group.

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* Pre-doctoral fellow of the National Heart Institute, National Institutes of Health.

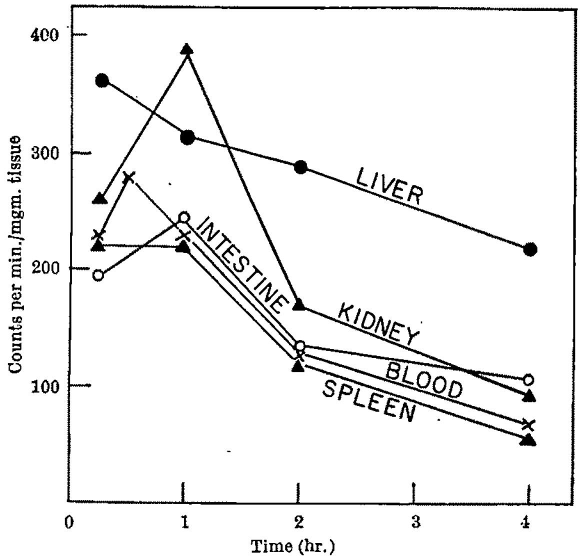

Fig. 1. The uptake of radioactivity by various organs of mice injected with labelled nicotinamide. Mice were injected intraperitoneally with 500 mgm. per kgm. of labelled nicotinamide (approximately 8×10^6 counts per minute per animal). The values for blood are counts per minute per 0·001 ml. whole blood. Radioactivity in other tissues was determined after dissolving the organs in boiling formamide

total acid-soluble nicotinamide, adenine, ribose and organic phosphate of mouse liver (Table 1). These changes are in good agreement with the increase in diphosphopyridine nucleotide. No change in adenosine phosphates or nucleic acid content of the liver has been detected.

These observations indicate that formation of diphosphopyridine nucleotide does not occur at the expense of adenine, ribose and phosphate already present in the liver. Rather, there must be either mobilization from extra-hepatic sources, or actual net synthesis of the required moieties.

Incorporation of Labelled Precursors

Incorporation of nicotinamide. This system has provided an unusual opportunity for detecting intermediates in the conversion of nicotinamide to diphosphopyridine nucleotide under *in vivo* conditions. The specific activities of some mouse tissues following the injection of nicotinamide labelled at its carboxyl group with carbon-14 are shown in Fig. 1. The relatively constant level of radioactivity in the liver while rapid synthesis of diphosphopyridine nucleotide is taking place suggests the presence of precursors. One of the radioactive compounds detected in the liver early in the synthesis has been identified as free nicotinamide. Another has been identified as the nicotinic acid analogue of diphosphopyridine nucleotide[7]. Forty-five minutes after the injection of labelled nicotinamide the specific activity of the analogue was twice as high as that of diphosphopyridine nucleotide. The analogue is present in the liver in largest amounts during the time the diphosphopyridine nucleotide is being synthesized, and in small amounts during the subsequent period of diphosphopyridine nucleotide degradation. These observations[8] indicate that the nicotinic acid analogue or possibly a labile carboxyl derivative of the analogue is an intermediate of the synthesis of diphosphopyridine nucleotide from nicotinamide. Preiss and Handler[9] have shown that the analogue is an intermediate in the *in vitro* synthesis from nicotinic acid by erythrocytes. Nicotinamide is a relatively inefficient precursor, the principal product formed being nicotinamide mononucleotide. In the whole mouse, however, nicotinic acid is a poor precursor, and an inhibitor of the formation from nicotinamide of both analogue and diphosphopyridine nucleotide. Removal of the amide group already present in nicotinamide during its conversion to diphosphopyridine nucleotide might indicate a requirement for a carboxyl substituted pyridine nucleotide as an intermediate at some step in the synthesis.

Incorporation of glucose. Evidence for an accelerated conversion of glucose to ribose during the biosynthesis of diphosphopyridine nucleotide has been obtained in experiments where glucose labelled with carbon-14 was administered together with nicotinamide[10]. The incorporation of ribose labelled similarly was also stimulated by nicotinamide. There was an increase in the specific activity of the ribose of both diphosphopyridine nucleotide and free adenylic acid. Incorporation into the nicotinamide ribose moiety of diphosphopyridine nucleotide was considerably greater than into the adenine ribose. When labelled glucose alone was administered, incorporation into the nicotinamide ribose of the endogenous diphosphopyridine nucleotide was also greater than into the adenine ribose, indicating a more rapid turnover of the nicotinamide ribose than the adenine ribose in the normal animal. As yet it is difficult to explain these results in terms of known enzymatic mechanisms.

The rapid conversion of glucose to ribose during the induced biosynthesis of diphosphopyridine nucleotide makes this system useful for studying pentose formation in the whole animal. Experiments in which differentially labelled glucose was administered with nicotinamide[11] have shown that in mouse liver not more than 5 – 10 per cent of the diphosphopyridine nucleotide ribose is formed by oxidative decarboxylation and that pentose synthesis can be explained largely in terms of the transaldolase–transketolase pathway[12].

Incorporation of phosphate. Administration of nicotinamide at 500 mgm. per kgm. stimulated fourfold the incorporation of inorganic phosphate labelled with phosphorus-32 into the diphosphopyridine nucleotide of mouse liver[8]. In contrast to the results with labelled glucose, there was no preferential incorporation into the nicotinamide phosphate of diphosphopyridine nucleotide.

Incorporation of adenine and its precursors. Nicotinamide administration stimulated slightly the incorporation of adenine-8-^{14}C into diphosphopyridine nucleotide without affecting incorporation into free adenylic acid. The incorporation of both glycine-2-^{14}C and formate-^{14}C into diphosphopyridine nucleotide, free adenylic and nucleic acid adenine was stimulated as much as five- to ten-fold by nicotinamide when incorporation was measured over a 1-hr. interval. When formate incorporation was measured over a 5-min. interval there was a fifteen-fold increase in specific activity of free adenylic acid but little change in the labelling of diphosphopyridine nucleotide. Nicotinamide had no effect on the incorporation of formate-^{14}C or glycine-2-^{14}C into liver protein.

When incorporation of formate, glycine, glucose and adenine was measured over successive half-hour intervals following injection of nicotinamide, the total incorporation of formate into diphosphopyridine nucleotide was found to increase, while the incorporation of other precursors either decreased or showed little change. This may indicate the occurrence of some exchange reactions.

The observation that the administration of nicotinamide can increase the incorporation of glucose, formate and glycine into free adenylic acid as well as into diphosphopyridine nucleotide suggests that there is actually a net synthesis of adenine and ribose rather than a transfer of these components into the liver for diphosphopyridine nucleotide synthesis. This should make the system synthesizing diphosphopyridine nucleotide useful for studying net purine synthesis over a short time period in the intact animal.

Metabolic Studies with altered *in vivo* Levels of Diphosphopyridine Nucleotide

Few studies of the effect of an elevated level of diphosphopyridine nucleotide in the liver on metabolism have yet been carried out. Smith *et al.*[13] have examined the effect of nicotinamide administration on ethanol metabolism in the whole mouse, in liver slices and in liver homogenates. The only difference observed was a two-fold increase in the rate of ethanol oxidation by liver homogenates prepared in a medium containing nicotinamide. They concluded that normal diphosphopyridine nucleotide-levels are adequate for ethanol oxidation in the whole animal or in liver slices, the limiting factor being enzyme concentration. In homogenates, where considerable destruction of endogenous diphosphopyridine nucleotide takes place by enzymes released from the tissue, increasing the diphosphopyridine nucleotide-content of the intact liver may help to maintain normal levels. We have found that the oxidation of formate-^{14}C to carbon dioxide in the whole mouse is also unaffected by nicotinamide administration.

Some Factors influencing Diphosphopyridine Nucleotide Synthesis

Effect of tumour growth. Waravdekar *et al.*[14] have reported that the growth of tumours in mice causes a decrease in the diphosphopyridine nucleotide content and diphosphopyridine nucleotide pyrophosphorylase activity of the blood. We have observed a 50 per cent reduction in the synthesis of diphosphopyridine nucleotide induced by nicotinamide (on a unit wet-weight basis) in the livers of mice bearing advanced leukæmia *L*-1210. This apparently reflected leukæmic infiltration and could be correlated with an increase in liver weight. There was actually little change in the amount of diphosphopyridine nucleotide synthesized per mouse. Treatment with amethopterin, which restored liver weights to normal, also restored synthesis. The growth of a number of solid tumours was found to have little effect on diphosphopyridine nucleotide synthesis in the liver.

Nicotinamide antagonists. These can affect the *in vivo* synthesis of diphosphopyridine nucleotide from nicotinamide in a number of different ways. Some pyridine derivatives, for example 3-acetylpyridine, are converted to nicotinamide in the body[2,3] and are capable of increasing the synthesis at low doses, or inhibiting it at high doses[3].

The effect on diphosphopyridine nucleotide synthesis of the nicotinamide antagonist 2-ethylamino-1,3,4-thiadiazole depends on the dose of nicotinamide. Inhibition was evident when the thiadiazole was administered with a high dose of nicotinamide, but with a low dose there was stimulation. These relationships may be of particular interest because the toxicity of the thiadiazoles and their anti-tumour activity can be prevented by nicotinamide[15,16] and thiadiazole can be incorporated into an analogue of diphosphopyridine nucleotide *in vitro*[16].

It is difficult to relate interference with diphosphopyridine nucleotide synthesis to toxicity. A single dose of one of the most potent nicotinamide antagonists, 6-amino nicotinamide, was not found to have any effect on this synthesis[3]. On the other hand, nicotinic acid, which is not generally considered to be a nicotinamide antagonist, was found to inhibit strongly the synthesis from nicotinamide[3].

Purine antagonists. The toxicity and antileukæmic action of 6-mercaptopurine can be prevented by administration of adenylic acid or a number of related compounds[17]. Diphosphopyridine nucleotide synthesis in mice is inhibited by 6-mercaptopurine and this inhibition can also be prevented by adenylic acid[1]. Similar results have been obtained with the purine antagonist thioguanine. In addition to decreasing the amount of diphosphopyridine nucleotide synthesized, these compounds also appear to interfere with the return of its levels to normal values at the end of 24 hr. following nicotinamide administration. In the case of 6-mercaptopurine this difference at 24 hr. can be as much as five-fold, and this effect of the drug is not reversed by adenylic acid[1].

Folic acid antagonists. The toxicity and antileukæmic action of aminopterin and amethopterin can be prevented by folic acid or some of its derivatives[18]. The folic acid antagonists are presumed to inhibit tumour growth by interfering with the biosynthesis of nucleic acids. Skipper *et al.* have reported decreased incorporation of formate-^{14}C into the nucleic acid purines of mice after treatment with aminopterin or amethopterin[19]. There have also been reports that such treatments actually stimulate *in vivo* incorporation of formate[20].

Amethopterin was found to have little effect on either the normal levels of diphosphopyridine nucleotide or upon *in vivo* synthesis following nicotinamide injection, even after extensive treatment. Similarly, experiments with mice bearing leukæmia *L*-1210 showed that this tumour retained its ability to synthesize diphosphopyridine nucleotide even while undergoing definite regression in size as a result of amethopterin treatment.

The incorporation of formate-^{14}C into mouse-liver diphosphopyridine nucleotide was found to be stimulated as much as eight-fold by treatment with amethopterin. Increased formate incorporation could be correlated with signs of toxicity such as weight loss, decreased leucocyte count and mortality. On a schedule of single daily treatments there was almost direct proportionality between the dose of amethopterin and formate incorporation (Fig. 2).

Increased formate incorporation into liver adenylic acid, nucleic acids and protein after amethopterin treatment could also be demonstrated when no nicotinamide was given. These observations may be related to the results reported by Barclay and Garfinkel[21]. They found that the incorporation of formate-^{14}C into liver proteins and nucleic acids was stimulated by treatment with N-methyl formamide, carbon tetrachloride or azaserine. They interpret this effect as a manifestation of hepatotoxicity.

Tranquillizing agents. The administration to mice of reserpine or promazine before the injection of

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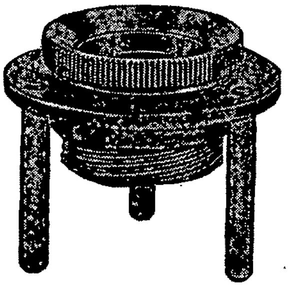

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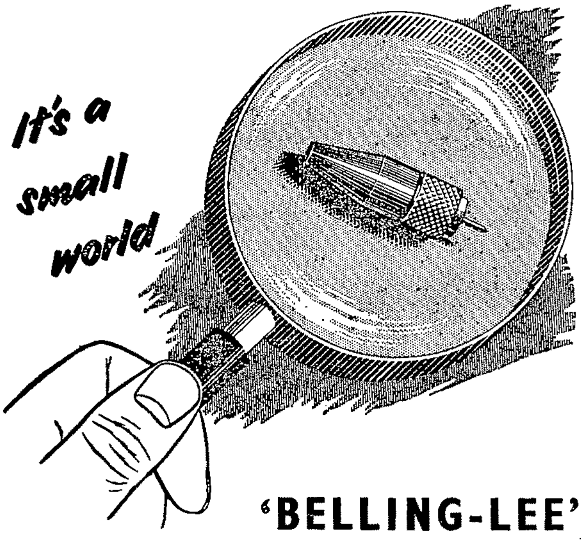

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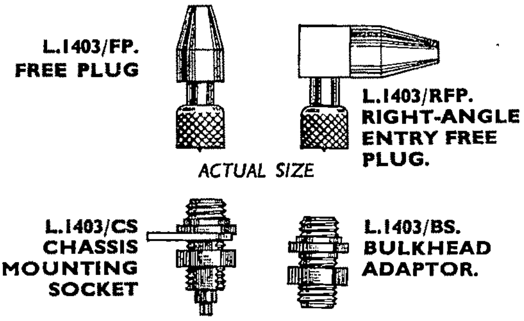
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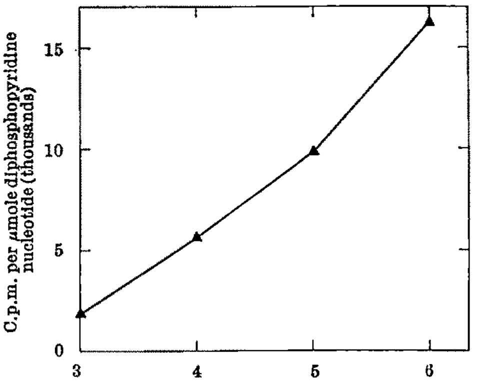

Fig. 2. Effect of daily treatment with amethopterin on the incorporation of formate-^{14}C into the diphosphopyridine nucleotide of mouse liver. Mice received daily subcutaneous injections of amethopterin for seven days. On the eighth day they were injected with 500 mgm. per kgm. of nicotinamide and formate-^{14}C. After 6 hr. the livers were homogenized with trichloracetic acid and the diphosphopyridine nucleotide isolated by ion-exchange chromatography

500 mgm. per kgm. of nicotinamide has little effect on the resulting increase in liver diphosphopyridine nucleotide, but prevents the return of its levels to normal at the end of 24 hr.[22]. High concentrations in the liver will then persist for as long as 48 hr. following the injection of nicotinamide. Whether this phenomenon results from some specific action upon the mechanisms which regulate the normal levels has yet to be resolved. When a number of reserpine derivatives were tested there was good correlation between their tranquillizing and anti-leukæmic effectiveness[23] and their ability to maintain the elevated level of diphosphopyridine nucleotide of liver following nicotinamide administration.

It is also of interest that reserpine will stimulate as much as ten-fold the incorporation of formate into the acid-soluble adenine of mouse liver. Such treatment has no effect on glycine incorporation or on the incorporation of formate into liver protein.

The investigations described here represent a few of the many fruitful ways in which diphosphopyridine nucleotide synthesis can be used to study biochemical mechanisms and the action of drugs in the whole animal.

This work was aided by grants from the National Cancer Institute, the National Institutes of Health (Grant *CY*-3611 Bio), the American Heart Association and the American Cancer Society.

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AN INFECTIVE 'RIBONUCLEIC ACID' COMPONENT FROM TUMOUR CELLS INFECTED WITH ENCEPHALOMYOCARDITIS VIRUS

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TREATMENT of tobacco mosaic virus with cold phenol gives preparations having up to 1 per cent of the original infectivity[1,2]; these are rich in ribonucleic acid, but contain too little virus protein to account for their infectivity. Since they are, moreover, highly unstable and can be rapidly inactivated by ribonuclease, it has been suggested that their infectivity is a property of ribonucleic acid released from the virus by phenol treatment[2], although this conclusion has been criticized on chemical grounds[3]. Phenol extracts of cells and tissues infected by several animal viruses have been shown to possess infectivity[4–6]. However, it is not clear (1) that the low infectivity is not due to residual intact virus; (2) that the infective material in phenol extracts comes from virus as such, and not from some other component of the infected tissue; or (3) that the infectivity is due to virus ribonucleic acid. Phenol extracts of infected cells will contain so much cellular ribonucleic acid that a minor non-ribonucleic acid component with virus activity might well escape detection.

We have been working with an *in vitro* and *in vivo* animal virus/host-cell system which may help to answer these questions. The first results reported here suggest that the infective material found in the aqueous phase following phenol extraction has properties which distinguish it from normal virus. Moreover, this material appears to come from some component of the infected tissue other than the virus itself.

Murine encephalomyocarditis virus is able to multiply to high titre in cells of the Krebs 2 mouse ascites carcinoma, maintained *in vitro* as continuously agitated cell suspensions[7]. With multiple infection (cells 10^7/ml.; virus 3×10^7/ml.) new virus first appears intracellularly about 4 hr. after infection, and reaches a maximum at 8 hr. Release of virus from a population of infected cells, beginning at 6–7 hr. after infection, occurs at a maximum rate between 9 and 11 hr. after infection, and is complete by 12 hr. The supernatant fluid then contains[8] about 1×10^9 plaque-forming units of virus per ml., and the same number of mouse ID_{50} when titrated *in vivo*.

Phenol extracts made either from culture fluids harvested at the peak of virus release (12–14 hr.), or from infected cells at various stages of the growth cycle, have demonstrable infectivity. Extractions were carried out at 4° C. by the method of Schuster *et al.*[9], and the preparations—henceforth termed 'ribonucleic acid extracts'—stored at − 70° C. Their infectivity for Krebs 2 carcinoma cells was tested in two different ways. (1) The ability of the material to infect static, non-dividing cells was tested by a plaque method of titration, using tumour cells suspended in agar[8]. (2) The activity of the material in a population of growing cells was tested by mixing it with suspensions of tumour cells, and injecting samples of 10^7 cells intraperitoneally into each of five mice per dilution. The encephalomyocarditis infectivity end-point was calculated by standard methods.

Table 1

Starting material	Virus content of starting material (plaque-forming units/ml.)	Infectivity of ribonucleic acid extract	
		By plating (plaque-forming units/ml.)	By mouse titration (MID_{50}/ml.)*
Supernatant from 14-hr. infected culture	2×10^9	45	4×10^4
		50	3×10^4
		30†	6×10^3
		20†	1×10^3
		400	5×10^4
		600	3×10^4
Infected cells			
2 hr.	1×10^6	5	10
4 hr.	$2{\cdot}8 \times 10^7$	125	5×10^3
8 hr.	$2{\cdot}2 \times 10^8$	95	3×10^3

* MID_{50}/ml., mouse infective doses/ml.
† Ethanol precipitated preparation.

Ribonucleic acid extracts made in the way described contained 5–600 plaque-forming units/ml. when plated on Krebs 2 cells (Table 1). The plaques formed appeared identical with those of the parent virus, and virus re-isolated from them had the expected properties. However, the plaque count for ribonucleic acid extracts in general did not diminish linearly with dilution, as already noted for eastern equine encephalomyelitis virus[5]. Plaque titration appears to measure the number of cells in the cell suspension used for titration which are 'competent' to take up active material from the ribonucleic acid extracts and make virus from it, rather than to estimate the total number of infective fragments present in the extract. This is borne out by the much higher titre shown by ribonucleic acid extracts when they are mixed with cells and titrated in mice (Table 1). Presumably a much higher proportion of cells become 'competent' under these conditions and are consequently able to produce virus. Further investigations of this cellular competence phenomenon will be reported in a later publication. Even when titrated in mice, ribonucleic acid extracts invariably had a titre much lower than that of the virus preparation from which they were made (Table 1).

The ultra-violet absorption spectra of ribonucleic acid extracts were measured in a 'Unicam' spectrophotometer. All preparations had a marked absorption peak at 260 mμ and a minimum at 240 mμ; the ratio of the adsorptions $\lambda_{260}/\lambda_{280}$ varied from 1·6 to more than 2. The concentration of ribonucleic acid was of the order of 2 mgm./ml. in terms of a commercial standard. All preparations tested appeared to contain some protein (20–150 μgm./ml.), but, since the Folin–Ciocalteu phenol reagent was used[10], these figures are presumably affected by any residual phenol present in the preparations, and their actual protein content may be much lower. All preparations, however, contained an enormous excess of cellular nucleic acid, mostly unrelated to the virus, so that chemical methods could not be used to show that the infectivity found belonged to viral ribonucleic acid alone and not to traces of other materials.

The infective material present in phenol extracts was, however, unlikely to be residual virus which had somehow escaped the inactivating effect of phenol. The infectivity of phenol extracts of mengo encephalitis and eastern equine encephalomyelitis viruses is destroyed by ribonuclease, and by incubation at 37° C., both treatments having relatively little effect on intact virus[4–6]. The infectivity of phenol extracts, moreover, can be precipitated with ethanol or 1 *M* sodium chloride, while that of virus is not so precipitated[5,6]. However, in some of the experiments already reported[4,6], the virus and ribonucleic acid preparations were not compared at equivalent levels of infectivity. Moreover, a possible 'protective' effect on virus of the large excess of normal cell ribonucleic acid in the phenol extract has not been considered. We have therefore tried to make comparison between an infective ribonucleic acid extract and encephalomyocarditis virus under as similar conditions as possible. Results are given in Table 2.

A phenol extract has been compared with encephalomyocarditis virus diluted to give a comparable plaque count; sufficient of a phenol extract of uninfected cells was added to the latter to give both preparations the same ultra-violet absorption at 260 mμ. Treatment with ribonuclease (10 μgm./ml.)

Table 2. COMPARISON OF PROPERTIES OF INFECTIVE RIBONUCLEIC ACID AND ENCEPHALOMYOCARDITIS VIRUS

Sample	Ribonucleic acid extract (MID_{50}/ml.)	Encephalomyocarditis virus (MID_{50}/ml.)
Control	3×10^2	1×10^3
After ribonuclease	0	$2{\cdot}5 \times 10^3$
After 1 hr. at 37° C.	10	7×10^2
After 1 hr. at 37° C. + 5 per cent rabbit serum	10	5×10^2
After 1 hr. at 37° C. + 0·1 per cent bovine plasma albumin	10	7×10^2
Sediment from ethanol precipitation (3 ×)	7×10^2	30
Sediment from precipitation with 1 *M* NaCl (3 ×)	$1{\cdot}6 \times 10^2$	70
	Ribonucleic acid extract (plaque-forming units/ml.)	Encephalomyocarditis virus (plaque-forming units/ml.)
Plating on normal cells (1)	20	120
(2)	20	
Plating on irradiated cells (1)	7×10^2	110
(2)	3×10^2	

for 15 min. at room temperature completely destroyed the infectivity of the ribonucleic acid extract, whereas that of the virus control was unaffected. Incubation at 37° C. for 1–1½ hr., either in the presence or absence of protein, reduces the titre of the ribonucleic acid preparation more than ten-fold, while that of the virus is only slightly affected. The ribonucleic acid extract can be precipitated and washed three times with 67 per cent ethanol or 1 *M* sodium chloride without significant loss of titre. However, the addition of 'carrier' ribonucleic acid to a dilute virus preparation also allows some of the infectivity to be carried through ethanol or 1 *M* sodium chloride precipitation; previously, it was found that both ethanol and 1 *M* sodium chloride failed to precipitate virus activity in the absence of carrier ribonucleic acid[5]. The above tests thus show that the material in ribonucleic acid extracts differs considerably from virus, particularly in its heat-lability and susceptibility to ribonuclease, but under our conditions precipitation by ethanol and molar salt cannot be held to show that the material is ribonucleic acid. Moreover, the biological activity of ribonucleic acid extracts differs from that of virus diluted to equivalent infectivity. First, there is the low titre shown by plating ribonucleic acid extracts compared with that shown by injection of the infected cells into mice (Table 1); encephalomyocarditis virus has the same titre both by plating and by mouse titration. Ribonucleic acid extracts and virus, diluted to a comparable level of infectivity, also behave differently when plated on Krebs 2 carcinoma cells which have been treated with ultra-violet light (cell concentration 10^7/ml., lamp 15 watts, 61 cm. distance, 2 min. exposure with agitation). Pre-treatment of cells in this way can increase the apparent titre of a ribonucleic acid extract ten-fold, whereas that of virus is not affected (Table 2).

Simple washing with phosphate-buffered saline of cells which have been treated for 30 min. *in vitro* with ribonucleic acid or virus did not remove virus from the cells, but rendered cell/ribonucleic acid complexes non-infective. Finally, treatment of ribonucleic acid/cell complexes, after 30 min. at room temperature, with either encephalomyocarditis antisera, or inactivated horse serum, destroys the infectivity, a treatment which is without effect upon virus-infected cells.

The amount of infectivity extractable by phenol from infected cells is not directly related to their virus content (Table 1; cf. 'virus' and 'ribonucleic acid' infectivities of 4 and 8 hr. cell samples). This suggested that the infectivity of material extracted with phenol might come from some component other than the virus itself. An infected culture fluid ($5 \cdot 8 \times 10^8$ plaque-forming units/ml.) was therefore centrifuged for 1 hr. at 105,000 *g*, and the supernatant removed and saved. Ribonucleic acid extracts were made from the supernatant, the sediment re-suspended to volume, and the stock from which these materials were prepared. The results are shown in Table 3. Although the virus content of the supernatant fluid was only one-thousandth of that of the sediment, the ribonucleic acid extract of the supernatant had more than ten times the infectivity of that extracted from the sediment. Two other preparations showed that even the residual infectivity of the sediment is probably due to contamination by supernatant material. Virus from a stock containing 2×10^9 plaque-forming units/ml. was concentrated and washed twice by centrifuging at 105,000 *g*; the two preparations contained 3×10^9 and 5×10^9 plaque-forming units/ml., respectively. Phenol extracts showed no infectivity either by plating or by mouse test.

Table 3

Sample	Virus content (plaque-forming units/ml.)	Infectivity of ribonucleic acid extract (MID_{50}/ml.)
Tissue culture fluid	$5 \cdot 8 \times 10^8$	$6 \cdot 3 \times 10^3$
(*a*) Supernatant from 1 hr. centrifuging at 100,000 *g*	$2 \cdot 2 \times 10^5$	$3 \cdot 0 \times 10^3$
(*b*) Sediment from 1 hr. centrifuging at 100,000 *g*	$1 \cdot 2 \times 10^8$	$1 \cdot 6 \times 10^2$
Sediment as in (*b*) washed (1)	5×10^9	0
2 × by centrifuging for 1 hr. at 100,000 *g* (2)	3×10^9	0

The infective material in phenol extracts may thus come from a component in the infected tissue which does not sediment to any extent under conditions which bring down virus. Treatment of infected cell homogenates with ribonuclease removes ultra-violet absorbing material without affecting the infectivity which can afterwards be extracted by phenol[6]. This indicates that the potentially infective material must normally be present intracellularly in a form resistant to the action of ribonuclease.

Ascites tumour cells infected with encephalomyocarditis virus, or the extracellular fluid into which virus has been released by the destruction of infected cells, thus contain, in addition to virus, a second component related in some way to virus synthesis. Phenol treatment breaks this material into fragments carrying the genetic information necessary for the production of virus. The origin and cellular location of this material and the part it plays in virus synthesis is at present wholly obscure. It could be a virus precursor, 'unpacked' viral genetic material incorporated in some cellular structure, or a form of viral ribonucleic acid which has failed to be assembled into complete virus.

When fragments enter competent cells, virus synthesis proceeds. The influence of such factors as ultra-violet light, injection into mice, etc., in inducing cellular competence may be best understood if we consider that virus infection has two distinct aspects. (1) Regarded as the most important until now, the production of new virus, which has been visualized essentially as the replication by the cell of a viral genetic pattern. (2) Since, immediately after virus infection, biosynthesis starts in the cell, we must postulate the existence of some stimulus which triggers the cell to synthesis. We can thus imagine that an infective virus particle carries both the genetic information and the trigger, while the material extracted with phenol carries the specific viral genetical information but lacks the trigger. In this case virus production will only occur when the cell is stimulated to synthesis by other means.

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LETTERS TO THE EDITORS

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Crystal Structure of Rhombohedral Sulphur

The allotropic form of sulphur first discovered by Engel[1] has been variously termed Engel's sulphur, S_ε, S_ρ, S_φ, trigonal sulphur, and rhombohedral sulphur. The molecule was shown to be hexameric by Aten[2]. Friedel[3] found the crystals were hexagonal prisms terminated by a flat rhombohedron. Although these crystals are largely converted to a mixture of plastic and orthorhombic sulphur an hour or so after they have been exposed to air or X-rays, Frondel and Whitfield[4] were able to determine the hexagonal lattice constants, show that the symmetry axis was three-fold, and demonstrate the absence of vertical planes of symmetry; the lattice constants, combined with the observed density[1], give 18 sulphur atoms per unit cell. The quality of their photographs was such that they were unable to determine whether the lattice mode was hexagonal or rhombohedral. Their X-ray study, however, combined with the morphological observations, established the point group as C_{3i}–$\bar{3}$, and Donnay[5] later pointed out that on purely morphological grounds the lattice is rhombohedral and that the space group is thus probably C_{3i}^2–$R\bar{3}$ (No. 148).

By taking rotation and small oscillation-range Weissenberg photographs around *a* and *c*, each with a different crystal, we have verified directly that the lattice is indeed rhombohedral. For the triply primitive hexagonal cell, we find the provisional values $a = 10{\cdot}83$ A. and $c = 4{\cdot}26$ A., in satisfactory agreement with Frondel and Whitfield's values of 10·9 kX. and 4·26 kX. The general position of C_{3i}^2–$R\bar{3}$ is six-fold; the primitive rhombohedral cell accordingly contains one molecule of S_6.

There are 31 unique (*hk*.0) reflexions accessible to $K\alpha$ copper radiation, and 25 of these have been observed. By the use of intensities estimated with the multiple film technique together with signs for the structure amplitudes obtained with the aid of a map of the molecular structure factor, we have prepared the projection of electron-density on (00.1), Fig. 1. The *x* and *y* parameters measured from this projection must be regarded as preliminary because neither series-termination effects nor errors due to absorption have been taken into account.

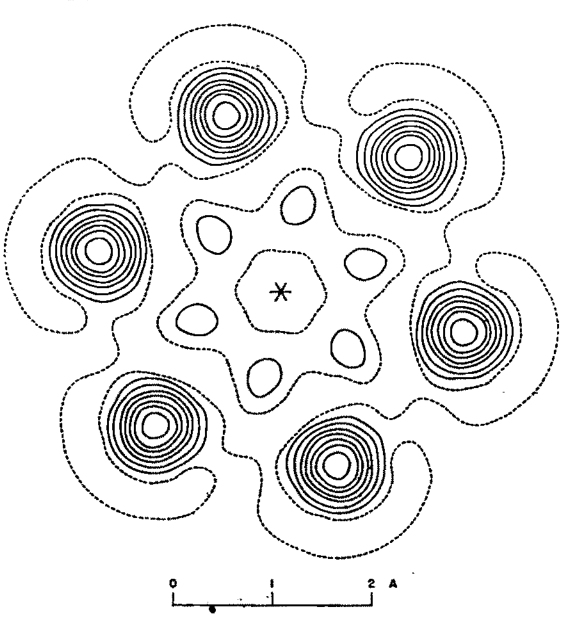

Fig. 1. Electron-density projected down the *c*-axis. Contours drawn at intervals of five electrons per A.^{2} (zero contour dotted)

Our (0*k*.*l*) photographs are somewhat poorer in quality than our (*hk*.0) photographs. Qualitative intensity considerations suggest a value of the *z* parameter of about 1/10. The fact that *z* is not zero means that S_6 molecules are staggered rings with symmetry D_{3d}–$\bar{3}m$. The approximate bond-length is 2·0 A., the bond-angle about 100°. We expect to obtain more precise values for these and other angles and distances of interest when the structure has been more completely refined.

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Aimery Caron
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Department of Chemistry,
University of Southern California,
Los Angeles, California. June 10.

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The Four Elastic Constants of Diamond

The thermal scattering of light in diamond has been studied in great detail by R. S. Krishnan[1] and by V. Chandrasekharan[2]. These authors pointed out that the frequency shifts observed for the Brillouin components are not in good agreement with the values calculated using the elastic constants data of Bhagavantam and Bhimasenachar[3]. The values of the elastic constants have since been determined by Prince and Wooster[4] and recently much more accurately by McSkimin and Bond[5]. McSkimin and Bond's values do not agree with those of Bhagavantam and Bhimasenachar and of Prince and Wooster, especially as regards C_{12} and C_{44}. Using the values of McSkimin and Bond, the frequency shifts of the Brillouin components for the various orientations studied by Chandrasekharan with the bigger spectrograph were calculated, but the agreement with the experimental values was still unsatisfactory. We have therefore evaluated the elastic constants of diamond directly from the observed frequency shifts[6].

To achieve this, three values of the frequency shifts must be assumed. For convenience, the shifts of the longitudinal component arising from the elastic waves moving approximately along the direction [$\bar{1}44$], which is inclined at about 10° to [011], and the longitudinal and transverse components of the elastic waves approximately along the direction [811], which is inclined at about 10° to [100], have been taken and, by a perturbation procedure[7], the elastic constants have been calculated. The values are $C'_{11} = 94{\cdot}9$, $C'_{12} = 15{\cdot}1$ and $C'_{44} = 52{\cdot}1 \times 10^{11}$. The accuracy is estimated to be 3–5 per cent, chiefly due to the errors possible in the angle of scattering. Using these elastic constants the effective elastic constants and the Brillouin shifts have been calculated for all the orientations and the results are given in Table 1.

Table 1*

No.	Incident light along	Scattered light along	Elastic wave nearly along	Nature of wave	Effective elastic constant		Brillouin shifts	
					Exp.	Calc.	Exp.	Calc.
1	$[2\bar{1}\bar{1}]$	[111]	$[\bar{1}44]$	long.	*108·2*	107·8	8·56	8·55
2	$[2\bar{1}\bar{1}]$	[111]	$[\bar{1}44]$	trans.	46·8	51·0 40·2	5·63	5·88 5·22
3	$[2\bar{1}\bar{1}]$	$[\bar{1}\bar{1}\bar{1}]$	[811]	long.	*96·6*	96·6	8·09	8·09
4	$[2\bar{1}\bar{1}]$	$[\bar{1}\bar{1}\bar{1}]$	[811]	trans.	*51·1*	51·9 50·7	5·88	5·93 5·86
5	$[2\bar{1}\bar{1}]$	$[01\bar{1}]$	$[31\bar{4}]$	long.	106·7	107·4	8·50	8·53
6	$[2\bar{1}\bar{1}]$	$[01\bar{1}]$	$[31\bar{4}]$	trans.	46·0	50·5 41·3	5·58	5·85 5·29
7	[111]	$[01\bar{1}]$	$[9\ 20\ \bar{2}]$	trans.	46·2	51·8 41·3	5·59	5·92 5·29

* Values in italics were used in calculating the elastic constants.

Agreement between the experimental and the calculated values of the frequency shifts is very good. It must be mentioned that the exact directions of the hypersonic waves were used in the calculations. It is of interest to see that the observed frequency shifts of the transverse components (cases 2, 6 and 7) are midway between the theoretical values arising from the two transverse waves. Because of their closeness, they were recorded as unresolved.

The values of C'_{12} and C'_{44} obtained by us agree very well with those of McSkimin and Bond, but disagree with the earlier measurements. There seems to be some slight disagreement in C'_{11}.

The values of the elastic constants given by the various workers are collected in Table 2. They fall into two sets, namely, C_{11}, C_{12}, C_{44} and C'_{11}, C'_{12}, C'_{44}.

(1) The values of C_{11} and C'_{11} for all workers agree closely, whereas C_{12} and C'_{12}, C_{44} and C'_{44} disagree very considerably.

(2) The bulk modulus calculated on the basis $\varkappa = (C_{11} + 2C_{12})/3$ agrees well with the observed values, whereas, as already shown by McSkimin and Bond, the value $\varkappa = (C'_{11} + 2C'_{12})/3$ does not agree with the experimental value (column 7 of Table 2).

(3) The values of $(C_{12} + 2C_{44})$ and $(C'_{12} + 2C'_{44})$ are equal (column 6) irrespective of the method of measuring the elastic constants.

These three significant results indicate very clearly that the interpretation of the experiments must be in terms of the atomic theory of elasticity due to Laval[8] and Raman[9], as a consequence of the existence of non-central atomic forces. The elastic behaviour of cubic crystals belonging to T_d, O and O_h classes could be described only by four elastic constants d_{11}, d_{12}, d_{44}, d_{45} and not by the usual three constants of Voigt's formulation. We designate the elastic constants obtained by using Christoffel's equation for the velocity of the linearly polarized plane waves in an infinite medium as the 'wave (dynamic) constants'. From the new theory of elasticity it is known that the values of the compressibility calculated using these constants will not agree with the observed value of the compressibility. Hence, we have identified the dashed quantities (C'_{ij}) in Table 2 as the 'wave (dynamic) constants'. In the pulse-phase comparison and thermal scattering methods the velocities are measured directly and hence the dashed constants are obtained. The undashed quantities (C_{ij}), on the other hand, can be designated as the 'static constants' because they agree with the compressibility data. The values of C_{12} and C_{44} obtained by Bhagavantam and Bhimasenachar fall in the latter (undashed) category. This may be due to the fact that although C_{12} and C_{44} have been calculated individually from the transverse wave equation, the torsional mode may have been excited in their experiments. It is not clear why Prince and Wooster's measurements should give the 'static' values. Probably the theory of diffuse scattering of X-rays needs some modification in the light of the new theory of elasticity.

The new theory demands the two invariants (1) and (3), the former only being pointed out by Viswanathan[10]. Using the following relations, the values of the four elastic constants d_{11}, d_{12}, d_{44}, d_{45} have been calculated.

$$d_{11} = C'_{11} = C_{11}\,;\ d_{44} = C'_{44}\,;$$

$$d_{45} = (2C_{44} - C'_{44})\,;\ d_{12} = (C'_{12} + 2C'_{44} - 2C_{44})$$

The average values of C_{ij} and C'_{ij} have been used to calculate the d_{ij}'s and the numerical values obtained are:

$$d_{11} = 101\cdot9\,;\ d_{12} = 36\cdot6\,;\ d_{44} = 54\cdot9\,;$$
$$d_{45} = 32\cdot1 \times 10^{11}$$

Table 2*

Authors	Method of measurement	C_{11}	C_{12}	C_{44}	$(C_{12} + 2C_{44})$	$(C_{11} + 2C_{12})/3$
Bhagavantam and Bhimasenachar	Wedge method	95	39	43	125	57·7
Prince and Wooster	X-ray diffuse scattering	110	33	44	121	58·7
Mean	—	102·5	36·0	43·5	123·0	58·2
		C'_{11}	C'_{12}	C'_{44}	$(C'_{12} + 2C'_{44})$	$(C'_{11} + 2C'_{12})/3$
McSkimin and Bond	Pulse phase comparison	107·6	12·5	57·6	127·7	44·2
Present authors	Thermal scattering	94·9	15·1	52·1	119·3	41·7
Mean	—	101·3	13·8	54·9	123·5	43·0
Williamson	Static	—	—	—	—	56·0
Theoretical	—	*101·9*	39·9 14·3	41·8 54·5	*123·3*	

* Values in italics were used in calculating the two unknown force constants.

Using these values three further relations have been verified:

$$(1)\ d_{12}\,(36\cdot6) = C_{12}\,(36\cdot0)$$
$$(2)\ (d_{11} + 2d_{12})/3\ (58\cdot4) = \kappa(56)$$
$$(3)\ d_{12} + d_{44} + d_{45}\ (123\cdot6) = C_{12} + 2C_{44}(123\cdot0) = C'_{12} + 2C'_{44}\ (123\cdot3)$$

The existence of the four elastic constants in diamond has thus been definitely established.

We note that in diamond, d_{12} is nearly equal to, but distinctly different from, d_{45}. This is what is to be expected from the (42) equations given by Viswanathan[10]. This difference between d_{12} and d_{45} is due to the lattice-displacement term, which is small even in diamond. In the case of other cubic crystals having all the atoms at the centres of symmetry, such as sodium chloride, this lattice-displacement term is zero and hence $d_{12} = d_{45}$; but d_{44}, in general, will not be equal to d_{45}. In diamond, the difference between d_{44} and d_{45} is large, as is to be expected from the pronounced covalent bonding.

The values of the four elastic constants can be calculated from the atomic force constants. The elastic constants have been evaluated otherwise by Viswanathan[10], but the two sets C'_{ij} and C_{ij} have not been clearly analysed. Taking the average values of $C_{11} = C'_{11}$ $(=101\cdot9)$ and $C_{12} + 2C_{44} = C'_{12} + 2C'_{44}$ $(=123\cdot3)$ and combining these with Ramanathan's[11] evaluation of the force constants from the spectroscopic behaviour of diamond to calculate the two unknown force constants, we get:

$$d_{12} = 39\cdot9\ ;\ d_{44} = 54\cdot5\ ;\ d_{45} = 28\cdot9 \times 10^{11}$$

The values for C_{12}, C_{44}, C'_{12} and C'_{44}, calculated on this basis, are given in the last row of Table 2. The agreement with the observed values is quite satisfactory, and affords further confirmation of our identification.

Accurate measurements of Young's modulus for diamond along the [100] and [111] directions would afford an additional test of the validity of the new theory of elasticity.

Work on other aspects of this problem is continuing and will be published in due course.

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Fluorescence of Adsorbed Water

IN previous communications[1] I have discussed what I called 'the reversibility of fluorescence by annealing' which I attributed in the case of chemicals and some pulverized minerals (anhydrite, desmine, colemanite) to adsorbed water, and in the case of the feldspars, which I studied in the form of larger pieces, to contamination by contact with the skin of the hand.

I have now observed the reversible fluorescence due to adsorbed water in feldspars which are sufficiently finely powdered, when the fluorescence destroyed by heating can also be regenerated by wetting or by long exposure to the air. Thus the greenish-blue fluorescence of these minerals can be attributed to adsorbed water which, in their natural state, is probably of magmatic origin. This explains the paradox that feldspars formed from the magma show a fluorescence that can be destroyed by heating; there is no evidence for radio photofluorescence in feldspars which might otherwise have explained this phenomenon.

The fluorescence of adsorbed water, first discovered by Ewles[2], is fairly widely distributed in the mineral kingdom. It is characterized by a broad band in the blue with one or two peaks between 430 and 480 mμ; it can be destroyed by strong annealing and regenerated by weaker heating after a short exposure to damp air, and by longer exposure to the atmosphere at room temperature, as well as by wetting. In many cases the fluorescence in the natural state is also increased by weak annealing.

The bluish colour of the fluorescence is often changed to orange-yellow by annealing, due to the relative enhancement of a long-wave band; it is not clear whether this is due to another activator or to the formation of certain lattice defects. This effect has already been observed in the case of calcite by Kreutz[3] and Déribéré[4], who also noticed the part played by water.

The reversibility of fluorescence by annealing has recently been found in alumina and silica under conditions which exclude any contamination; the only substances with which the powders were in contact, apart from the air of the room, being the interior of Jena glass tubes and platinum cleansed by heating to yellow heat.

Wawilow and Tummermann[5] have observed a bluish fluorescence of water that can be removed only with difficulty by repeated distilling. I have now found that freshly fallen snow and its melt-water, excited by ultra-violet light, display a bluish fluorescence with a peak at 430 mμ, in sufficient agreement with the results of Wawilow and Tummermann. Those authors tentatively ascribe the fluorescence to oxygen, whereas Ivekovic[6] attributes it to organic impurities. It seems possible, however, that this fluorescence, too, may be due to the adsorption of water, not on a solid body but on the molecules of some impurity.

As to the fluorescence of skin[1, 7], which first led to a mistake in the case of the feldspars, the following observations may be added. The aqueous extract of heated skin is brightly fluorescent; on evaporation a brown deposit is formed which is only faintly fluorescent. Rewetting, however, immediately restores the fluorescence.

I wish to thank Dr. H. Adler for his help in these investigations.

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Energy Spectrum of Particles Bombarding the Earth

Interstellar matter may be captured by the gravitational field of the Sun. Harrower[1] suggests that this matter is intercepted by the Earth's atmosphere at the 400-km. level, giving rise to radio-star scintillation. He estimates[1] the flux of hydrogen atoms or nuclei of about 10 eV. as of order 10^{13} cm.$^{-2}$ sec.$^{-1}$.

Balmer emissions with Doppler shifts corresponding to proton velocities of order 1,000 km./sec. (energy 10^4 eV.) have been observed in auroral displays. The flux of protons has been estimated[2] as of order 10^7–10^8 cm.$^{-2}$ sec.$^{-1}$. Protons coming from outside the Earth's atmosphere and penetrating to auroral depths must have incident energies of order 10^5 eV. Very little is known about when and where auroral protons reach the Earth.

In the energy region above 10^9 eV., cosmic rays follow an integral energy (E) spectrum given[3] by $N\ (>E) \propto E^{-1 \cdot 5}$. The exponent may increase for $E > 10^{16}$ eV.

The cosmic-ray integral energy spectrum is plotted as a solid line in Fig. 1. The estimated fluxes of interstellar and auroral particles appear to fit the straight-line portion of this spectrum extrapolated to lower energies.

This fit could not be predicted *a priori*, and according to present theories it must be fortuitous or based on inaccurate estimates. Clearly, it is important to examine the intermediate energy intervals.

As shown in Fig. 1, the cosmic-ray spectrum appears to be cut-off at an energy of about 10^8 eV. However, it is known that the flux of particles in this energy region varies greatly with solar activity[4]. It may be supposed, then, that this cut-off is due to some solar influence[3].

The geomagnetic field and the shielding nature of the atmosphere also influence measurements in the energy-range about 10^5–10^8 eV. However, Winckler *et al.*[5] have found a possible association between cosmic radiation and auroral activity. Also Van Allen and others[6] measured the flux of soft radiation at rocket altitudes as much greater at the northern auroral zone than elsewhere.

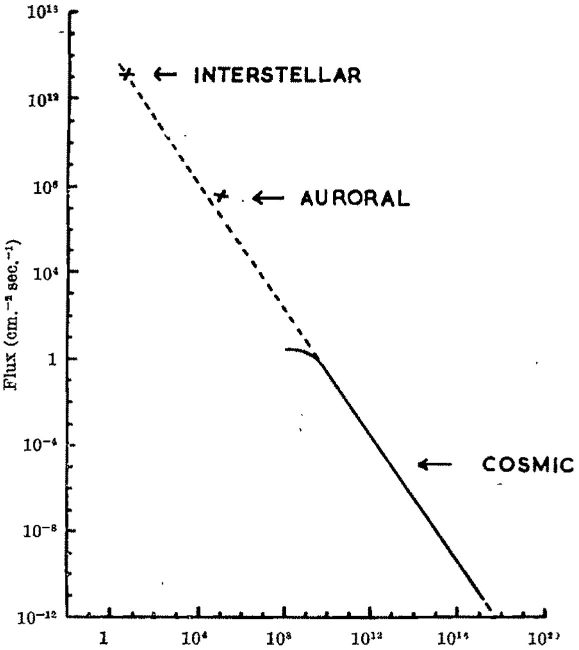

Fig. 1. The integral energy spectrum of particles entering the Earth's atmosphere. The cosmic-ray spectrum is shown as a solid line

Recent measurements using artificial Earth satellites have indicated that the flux of ionizing radiation at an altitude of 1,000 km. is about one thousand times the flux at 100 km. This might be interpreted as further evidence for a continuation of the energy spectrum between 10^6 and 10^8 eV.

The energy-range around 10^5 eV. could be studied by examining height-intensity distributions of auroral Balmer emissions. No accurate measurements are available, and the point plotted in Fig. 1 represents the integral flux estimated by several workers[2]. Chamberlain has found[2] that an integral energy spectrum of $E^{-1/2}$ may govern the auroral protons. However, the uncertainties in this estimate are considerable.

To my knowledge, no quantitative measurements in the energy-range between 10 and 10^5 eV. have been reported.

Since first considering the data presented in Fig. 1, I have seen a recent paper by Parker[7]. He has shown that the cosmic-ray gas can be effectively coupled to motions of ordinary matter, and that this represents a state of general dynamic balance. This treatment suggests that the relation noted in Fig. 1 may not be fortuitous. Clearly, much more theoretical and experimental study of the problem is essential.

Stimulating discussions with members of the Antarctic Division are gratefully acknowledged.

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Coherent Scattering of 1·33 MeV. γ-Rays by Lead

The cross-section for coherent (elastic) scattering of γ-rays from a heavy atom is expected to include a contribution from Delbrück scattering, the scattering of light by a static electric field[1]. This contribution should appear as a deviation of the experimental cross-section from the cross-section calculated taking only Rayleigh scattering and nuclear Thomson scattering into account; but uncertainties in both theory and experiment have made it difficult to draw any definite conclusions from the results at low energies[2,3].

We have measured the differential cross-section for elastic scattering of 1·33 MeV. γ-rays from lead using a larger γ-ray source than previous workers[2], and using a different method[4] of examining the scattered γ-ray spectrum. In this method a scintillating crystal is viewed by two photomultipliers 1 and 2, the spectrum of 'gated' pulses from 1 being recorded: thus a pulse from 1 is recorded if it coin-

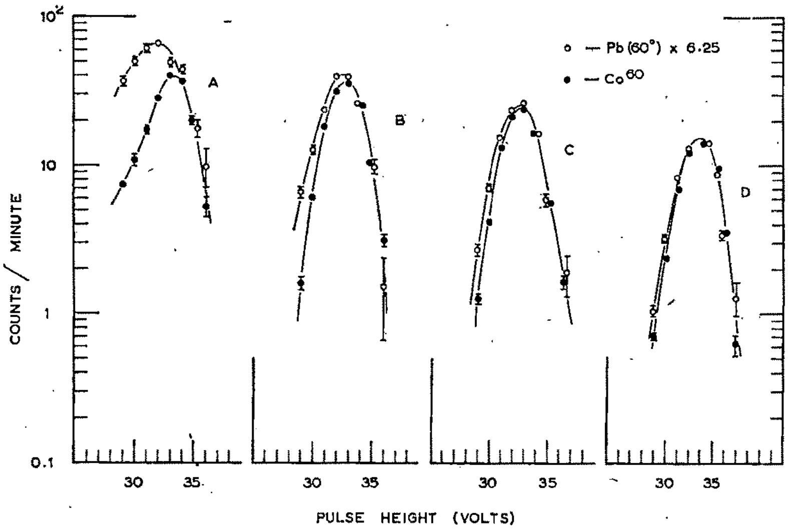

Fig. 1. Gated pulse-height spectra recorded in photomultiplier-1 for various gate voltage settings in photomultiplier-2—the gate voltage increases going from *A* to *D*. ○, γ-Rays scattered from lead at 60°; ●, γ-rays from the small cobalt-60 source *b* at the target position. The counting-rate from the scattered γ-rays has been multiplied by 6·25 in each case

cides with a pulse from 2 greater than a 'gate voltage' *V*. By increasing *V*, the proportion of inelastic scattering included in the measured elastic scattering cross-section may be made negligible.

γ-Rays from a cobalt-60 source *a* (about 1,500 curies) impinged on a lead target (15 cm. × 15 cm.) and the scattered radiation was observed by a NaI(*Tl*) crystal (about 20 cm.^{3}) shielded from background by about 1,200 lb. of lead. The distances source–target and target–crystal were both about 100 cm., so that the angular resolution was between 1 and 2 deg. Measurements under identical conditions were alternated between the scattered radiation (n_a counts/min.) and the direct radiation from a small cobalt-60 source *b* placed at the target position (n_b counts/min.). In each case, light pulses from the crystal were viewed by two photomultipliers[4] as described above. Fig. 1 shows the recorded pulse-height spectra. If no inelastic scattering is being recorded the scattered γ-ray spectrum should have the same shape as the spectrum of the cobalt-60 source. It is clear from Fig. 1 that for low gate voltage considerable inelastic scattering was included—from experiments with thin targets we have found this to be mainly a primary effect (and not a secondary effect of photoelectrons produced by the γ-rays in the target) and to be qualitatively consistent with the Compton scattering expected from bound electrons[5]. As the gate voltage was raised (Fig. 1) the scattered γ-ray spectrum approached that of the cobalt-60 source, giving the ratio n_a/n_b directly. Corrections were made for background ($\lesssim$ 30 per cent) and for target absorption ($\lesssim$ 15 per cent).

At every angle sufficient lead absorber (1–3 in.) was put between the target and the counter to make pile-up negligible. To guard against systematic errors caused by a shift of photomultiplier gain with counting-rate[6], the small cobalt-60 source was accompanied by a cæsium-137 source large enough to give a total photomultiplier current equal to that when the scattered radiation was observed. In addition, we selected as one of our photomultipliers a tube having a gain which increased with increasing counting-rate, and as the other a tube having the opposite characteristics—the change of gain with counting-rate was of the same order of magnitude in the two cases. Measurements taken when first one and then the other of these photomultipliers acted as gating tube, gave upper and lower limits on the ratio n_a/n_b. In all cases, except for the smallest two angles, these agreed within the standard deviations, and for the smallest angles we believe that the combined results are within the standard deviations.

The absolute scattering cross-section is determined by the ratio n_a/n_b, the number of target atoms, the source–target distance, and the ratio *a*/*b* of source strengths. The ratio *a*/*b* was measured in two steps, using an intermediate source *d* of about 150 mc. First the ratio *d*/*b* was measured directly by counting the γ-rays from the sources under identical conditions. Then absorption curves for *a* and *d* (overlapping for a half-thickness) were taken with the same geometry for each. Both curves were exponential and gave an absorption coefficient agreeing with Colgate's value[7], so their ratio was taken for *a*/*d*.

Our experimental cross-sections are shown in Fig. 2. They are lower than those of Bernstein and Mann[2] by factors of 1·3–2·5, and also are much lower than the earlier experimental results[2], but are in fair agreement with the measurements of Goldzahl and Eberhard[2] within the errors of the latter (± 20 per cent).

Fig. 2 also shows the theoretical coherent scattering cross-section. The *K*-shell Rayleigh scattering was

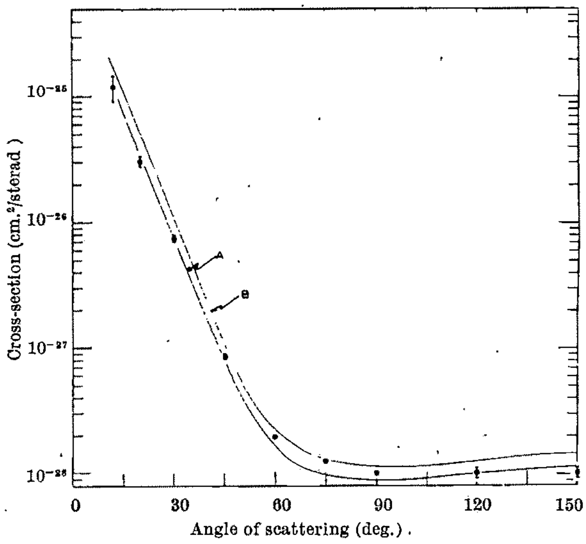

Fig. 2. Coherent scattering cross-section of 1·33 MeV. γ-rays from lead. The points are our experimental points and the bars are standard deviations—where bars are not shown the standard deviations are smaller than the size of the points. In addition to these errors there is an error of ± 5 per cent common to all the points, corresponding to errors in the measurement of the source ratio *a*/*b*. *A*, Theoretical cross-section for nuclear Thomson scattering and Rayleigh scattering from the *K*-shell only; *B*, theoretical cross-section for nuclear Thomson scattering and Rayleigh scattering from the *K*- and *L*-shells

calculated from Brown and Mayers's exact calculations for mercury[3]. These were corrected to lead by multiplying the amplitude for polarization change by the ratio of form factors at each angle, and by multiplying the amplitude for no polarization change by the ratio of Brown and Mayers's 'corrected form factors' at each angle, giving corrections less than, or approximately equal to, 15 per cent in cross-section. The *L*-shell scattering was calculated from the form factor for polarization change and from the 'corrected form factor' for no polarization change.

It is clear from Fig. 2 that if the theoretical results for *K*- and *L*-shells are taken literally, we find an appreciable difference between theory and experiment, amounting, for example, to about 30 per cent at 30°. This difference appears to be qualitatively consistent with present theoretical knowledge of Delbrück scattering[8]. Unfortunately, however, the only accurately calculated Rayleigh cross-section is for scattering from the *K*-shell in mercury[3], and the corrections from mercury to lead and for the contribution of the *L*-shell are of the same order of magnitude as our difference. Furthermore, it appears likely, from the results for the *K*-shell[3], that our *L*-shell calculation is a considerable over-estimate. Therefore, we believe that a final answer as to the presence of Delbrück scattering in our experimental results must await more accurate calculations.

A more detailed report on this work will be published in the *Canadian Journal of Physics*. We are particularly indebted to the Manitoba Cancer Foundation for permission to use its cobalt-60 beam-therapy unit and to the National Research Council of Canada for financial support. We also thank Dr. A. Bernstein, Dr. G. E. Brown and Dr. A. K. Mann for informative discussions and for communication of their results before publication, and Mrs. P. Barnes and Mr. G. Hardie for valuable assistance.

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Structure of Precipitated Apatitic Phosphates

TRICALCIUM phosphate (calcium/phosphorus weight ratio, 1·94) is thought to be hydroxylapatite (calcium/phosphorus, 2·15) with phosphate ions chemisorbed. When immersed in lime solutions, this tricalcium phosphate becomes more alkaline and the ratio rises to 2·15. Kinetic studies of lime fixation show that the reaction is not instantaneous. Therefore, it is questionable whether phosphate ions previously in excess should be located on the surface only. On the other hand, the existence of cation defects in the crystalline lattice itself is unlikely.

We think that precipitates of synthetic phosphates must be especially tiny microcrystals, more or less agglomerated, in bigger particles. In such agglomerates, properties connected with structure are not necessarily the same as in perfect macrocrystals. This would account for some properties of the iso-ionic exchange, as well as for other properties of synthetic precipitated phosphates[1].

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Catalytic Activity and Surface Structure after Ion Bombardment

SINGLE crystals of silver have been prepared with surfaces having an orientation within 2° of the (111) plane. After bombardment with low-energy argon ions the surfaces have been studied by: (1) measurements of the rate of the catalytic decomposition of formic acid (zero-order reaction); (2) electron diffraction in transmission and reflexion. The results of these experiments suggest that the catalytic decomposition of formic acid on silver occurs at points on the surface where dislocation lines emerge.

Catalysis. The reaction-rate was always expressible as a function of the absolute temperature, T, in the form $A \exp(-E/RT)$. When this was done, both A and E changed with the energy of the bombarding ions. For example, for a maximum ion energy of 14 eV. the value of E was 12·2 kcal./mole; for a maximum ion energy of 77 eV. E became 20·8 kcal./mole and the value of A increased by a factor of $10^{5\cdot2}$. In these experiments the same crystal was used as the catalyst after bombardment with ions of various energies, and the changes in E and A have clearly to be ascribed to a change in the surface due to the bombardment.

We have been able to account for the changes in A only by supposing that there is an increase in the number per unit area of 'active places' on the surface where the reaction can occur. The important feature of these specific sites may be geometric or electronic or both. Assuming that for a given treatment there is mainly one type of site, so that A gives a simple measure of the number of sites, we can say that this number has been increased by the bombardment by a factor of at least $10^{5\cdot2}$. This large increase must be associated with a change in the number of surface defects caused by ion bombardment. Since the crystal is annealed at 250° C. before the measurements are made—and at this temperature defects other than dislocations are reduced to low numbers—this change is most likely to be the result of a change in the number of dislocation lines intersecting the surface.

Electron diffraction. Evidence supporting this last conclusion was obtained from the electron diffraction studies. Bombardment at 14 eV. produced no detectable structure changes in the surface, although silver was removed. Bombardment at 77 eV., however, resulted in the surface layer down to about 100 A. becoming disoriented, small crystalline blocks being rotated with respect to one another mostly through angles of a few degrees. The low angle boundaries between these blocks are commonly described in terms of arrays of dislocations, and the disorientation was found to be comparable to that produced in a crystal of a very heavily cold-worked polycrystalline aggregate in which it is well known that the number of dislocations is about 10^5 times that in an annealed crystal. This implies that the increase in the number of dislocation lines cutting the surface after bombardment at 77 eV. is of the order of 10^5 times the number after bombardment at 14 eV. This increase is similar to that in the number of sites found from the catalytic experiments. We therefore consider that the electron diffraction evidence gives strong support to the conclusion that dislocations cutting the surface provide sites for the reaction.

This work will be fully reported elsewhere.

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Tritium and Paper Chromatography

Since hydrogen is an element of fundamental interest in life processes, it is important to have a method for studying its pathway through living systems. If, in paper chromatography, one is using a radioactive tracer, a sheet of X-ray film can be placed on top of the chromatogram and the labelled compounds then produce darkened spots on the film[2]. Unfortunately, in the case of hydrogen, only tritium is radioactive, and this decays by the emission of a very soft β-particle (18 keV.), the range of which is so low that it is absorbed before it can leave the paper and enter the film. This communication describes a technique of 'scintillation autography' whereby this difficulty is overcome. The technique involves soaking the chromatogram in a liquid scintillator so that the energy of the disintegrating tritium atoms is converted into light which is detected by a film. Thus a weak β-particle is converted into light quanta which can travel into the film to produce an image. By the use of fast film, small amounts of compounds labelled with tritium can be separated and identified in only a few days.

This technique is used in our laboratories for researches on the path of hydrogen in photosynthesis. A typical experiment is described to illustrate the technique.

25 mgm. of washed algae (*Chlorella*) are centrifuged to the bottom of a conical centrifuge tube. As much water as possible is removed, since it will lower the specific activity of the tritiated water. 50 mc. tritiated water (4 c./ml.) are added under the particular conditions of the experiment and the whole rapidly agitated with a stream of air with 4 per cent carbon dioxide. At the end of the experiment absolute methanol is added to kill the algae. After extraction with alcohol and water, the extracts are evaporated under vacuum and placed on one corner of a piece of Whatman No. 4 filter paper (15 cm. × 15 cm.) washed in oxalic acid. After development the chromatogram is attached to some suitable backing material with wire staples (used X-ray film is suitable). A spot of extract from algae or yeast labelled with tritium is placed on a piece of filter paper and when dry cut into segments. These segments are then attached to the corners of the backing sheet with staples. These later provide reference points on the backing sheet and also on the film with which to line up the film and the original chromatogram, thus identifying a spot with a definite area on the paper chromatogram. The backing sheet thus prepared is laid in the bottom of a shallow tank and covered with a scintillating liquid (for example, 3 gm./l. *p*-diphenyl benzene in sulphur-free toluene). A sheet of film is next placed on top of the chromatogram, taking care to eliminate any bubbles. The tank is then covered with an air- and light-tight top. After a few days, the film is removed from the tank, drained of scintillating liquid and allowed to dry. It is then developed and fixed in the normal manner. Such a 'scintillation autogram' is shown in Fig. 1. Thus, as in carbon-14 radioautography, compounds can be tentatively identified by their position and this identification confirmed by removal from the paper and co-chromatography with known compounds, or by chemical treatment and re-chromatography.

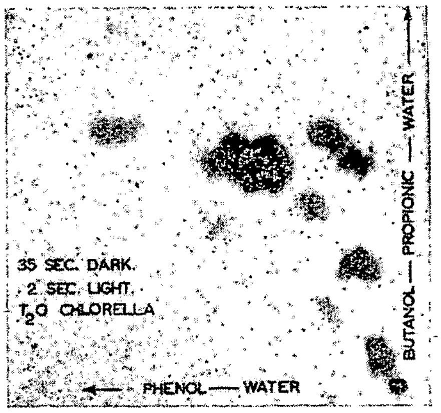

Fig. 1. Example of scintillation autograph

As can be seen, the quality and sharpness compares favourably with radio-autograms produced by beta-particles from carbon-14. Although this technique has been used to study the 'photo' part of photosynthesis in our laboratories, it could also be applied to many other biological and chemical problems. In view of the cheapness and availability of tritium (10^{-4} that of carbon-14), and also the ease of its introduction into complicated organic molecules (by exposure to tritium gas[3]), it should be possible to use it to discover the biological fate of some of the more complex organic materials which are difficult to synthesize with carbon-14. This new technique also provides a method of preparing chromatographically pure tritium-labelled compounds. This overcomes the principal difficulty in the Wilzbach synthesis[3], which yields a product contaminated with small amounts of tritium-labelled material of high specific activity, the removal of which by other means is both tedious and difficult.

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A New Method for preparing Scaly Alumina

SCALY alumina is a hydrous alumina with white iridescent scales, similar to white mica sheets. It was first prepared by Neogi and Mitra as the product of the reaction of aluminium amalgam with aqueous barium nitrate solution[1]. The conditions for the formation of scaly alumina were re-investigated by Biltz and Lehrer[2], who found that a saturated barium nitrate solution, at room temperature, gives the highest yield of well-formed sheets of scaly alumina. Neogi and Mitra gave the composition $Al_2O_3.4H_2O$ for the scaly alumina, but this was not confirmed by Weiser[3]. Scaly alumina was considered by Weiser to be a form of Wislicenus's fibrous alumina, but this is not true, since fibrous alumina is formed in conditions different from those in Neogi and Mitra's or Biltz and Lehrer's methods[4].

During studies on the fine structure of scaly alumina by electron microscopy, X-ray diffraction and differential thermal analysis[5], a new method was developed for preparing scaly alumina using hydrogen peroxide instead of the barium nitrate solution. This new method yields a substance identical in appearance to the scaly alumina prepared by the other methods, with the advantage that it is free from the barium and ammonium compounds which are formed in the reduction of the barium nitrate by the aluminium amalgam.

The procedure for preparing the scaly alumina is as follows: a 6 cm. × 6 cm. piece of 99·95 per cent pure aluminium sheet, 0·5 mm. thick and weighing about 5 gm., is washed in a 1-litre beaker, first with acetone, then with *N* sodium hydroxide solution and finally with distilled water to remove the sodium hydroxide; 100 ml. of a saturated mercuric chloride solution are added to the beaker and left to react with the aluminium until the latter is covered with an adherent layer of liquid mercury; the greyish turbid liquid is rejected and the amalgamated aluminium sheet is washed five times with 500 ml. of distilled water to remove the mercury salts; 1 kgm. of twice distilled mercury is added to the beaker, and immediately followed by the addition of cold 3 per cent hydrogen peroxide solution. The amalgamated aluminium sheet floats on the surface of the mercury, covering it almost completely and starts reacting with the hydrogen peroxide solution, with a strong production of gas and heat. The beaker is placed in a refrigerator at 4–5° C. to slow down the reaction; after 24 hr. the surface of the mercury is covered with a thick layer of white iridescent sheets of scaly alumina.

The scaly alumina may be separated from the hydrogen peroxide solution and from the mercury by filtration in a Buchner funnel without filter paper, and washed with distilled water. It must be dried at room temperature, in air or in a vacuum desiccator to preserve its iridescent scaly appearance, which is lost when it is dried at more than 70° C. The amount of scaly alumina obtained by this procedure corresponds to a yield of 40–45 per cent from the original weight of the aluminium sheet. The amalgamated aluminium sheet, floating on the surface of the mercury, gives better sheets of scaly alumina than does the aluminium amalgam, prepared from aluminium powder[6], in Biltz and Lehrer's method[2]. If the reaction is allowed to proceed until all the hydrogen peroxide in the solution is used up or if the temperature becomes too high, no scaly alumina is formed, but a dark grey powder appears, as in the reaction of strongly amalgamated aluminium with water[7].

Table 1

Substance	Loss on ignition (per cent)
Scaly alumina, Biltz and Lehrer's method (ref. 2)	31·4
Scaly alumina, H_2O_4 method	38·3
$Al_2O_3.3H_2O$ (theoretical)	34·7
$Al_2O_3.4H_2O$ (theoretical)	41·4

Table 1 shows the results of the determinations of the loss of weight on ignition at 1,200° C. of samples of scaly alumina prepared by Biltz and Lehrer's methods and by the procedure described above. These results are for samples dried at 110° C. to constant weight. For comparative purposes, the theoretical ignition losses of an alumina trihydrate and a tetrahydrate are also presented in the table.

These results show that the scaly alumina prepared by Biltz and Lehrer's method is closer in composition to an alumina trihydrate than to a tetrahydrate. The lower ignition loss is probably due to barium impurities adsorbed between the layers of the scaly alumina. The scaly alumina prepared by my method is closer in composition to an alumina tetrahydrate; however, no alumina tetrahydrate exists[8], only the mono- and tri-hydrates. Therefore, the scaly alumina prepared using hydrogen peroxide solution must be an alumina trihydrate with some water adsorbed between the layers. These results are confirmed by the X-ray powder diffraction data of the samples prepared by both methods[5]. A detailed study on the structure of the scaly alumina will be published elsewhere.

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α-(*p*-Nitrophenyl)Maltoside as a Substrate for the Assay of Amylase

RECENT methods for the assay of amylase use polysaccharides, mostly starch solutions, as a substrate. The wide range of the results can be ascribed in part to the properties of polysaccharides in solution. In starches the ratio of amylose to amylopectin is variable and, according to Meyer, long-chain polysaccharides in solution tend to form particles resistant to enzyme. The affinity of amylase for the substrate diminishes with decreasing chain-length. The maltose set free acts as an inhibitor of amylase (cf. Meyer *et al.*). Moreover, the moderate accuracy of the usual (iodometric and reductometric) methods of measuring chain-length may affect the results unfavourably.

An improved method for the assay of amylase seemed possible, using maltotriose as a substrate.

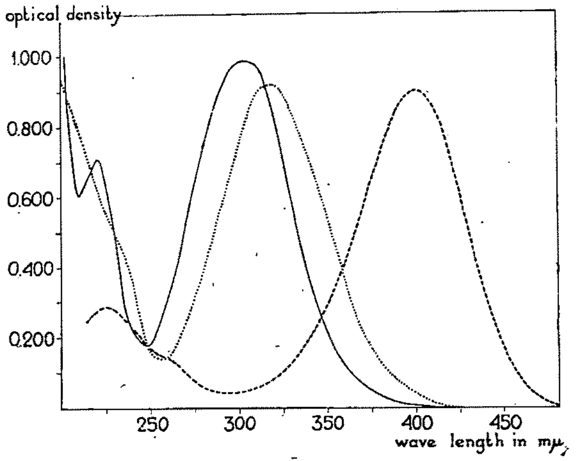

Fig. 1. Absorption spectra of α-(*p*-nitrophenyl)maltoside in acid and alkaline solution (solid line) and of *p*-nitrophenol in acid (dotted line) and alkaline solution (interrupted line). 'Unicam' spectrophotometer 500, 10-mm. cuvettes, intervals of 5 mμ.

However, unanimity does not exist about the action of amylases on maltotriose. According to Meyer *et al.*[1] and Pazur *et al.*[2], maltotriose is broken down to glucose and maltose at a very slow rate, whereas Wheelan *et al.*[4] and Myrbäck *et al.*[5] deny that maltotriose is degraded by salivary amylase.

We have studied the breakdown of maltotriose photometrically, using α-(*p*-nitrophenyl)maltoside as a substrate. The strong yellow colour of *p*-nitrophenol, set free during hydrolysis, makes it possible to measure a slight degradation and to avoid high concentrations of maltose.

Synthesis of α-(*p*-nitrophenyl)maltoside was performed by the following procedure, analogous to the synthesis of 4-methyl-α-(*p*-nitrophenyl)glucoside by Berger[6]:

$$\text{Maltose} + \text{acetic anhydride} \rightarrow \text{octa-acetylmaltose}$$

$$\text{Octa-acetylmaltose} + p\text{-nitrophenol} \xrightarrow{\text{TiCl}_4} (p\text{-nitrophenyl})\text{hepta-acetylmaltoside}$$

$$(p\text{-Nitrophenyl})\text{hepta-acetylmaltoside} + \text{methanol} \xrightarrow{\text{sodium methylate}} \text{methylacetate} + p\text{-nitrophenyl maltoside}$$

Titanic chloride catalyses formation of the α-form of glycosidic linkage[6]. Absorption spectra of the amorphous substance in alkaline and acid solution were identical, indicating linkage of the phenolic OH-group of *p*-nitrophenol to maltose (Fig. 1). *p*-Nitrophenol was set free while boiling with alkali.

Hydrolysis of the substrate was obtained during incubation with saliva, urine, duodenal contents and incidentally with serum.

Table 1. Influence of High Temperature (boiling 15 min.) and Protein Precipitants on Hydrolysis of α-(*p*-nitrophenyl)maltoside by Human Urine and Saliva, expressed as Optical Density at $\lambda = 410$ mμ

	Untreated	Boiled	10 per cent trichloracetic acid		0·5 *N* silver nitrate
			0·1 ml.	0·2 ml.	0·1 ml.
Urine	0·190	0·020	0·090	0	0
Saliva	0·320	0	0·130	—	0

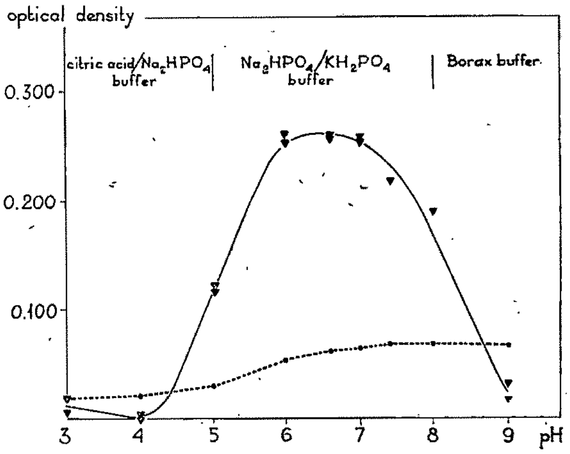

Fig. 2. Relationship between *p*H and hydrolysis of α-(*p*-nitrophenyl)maltoside by human urine, expressed as optical density at $\lambda = 410$ mμ. The dotted line represents the hydrolysis of the blanks, measured against water

2 mgm. of substrate, dissolved in 3 ml. of 1/15 *M* phosphate buffer (*p*H 6·5) were incubated with 0·1 ml. of the material to be tested at 37° C. for 16 hr. Then 10 ml. of 0·02 *N* sodium hydroxide were added. Production of *p*-nitrophenol was measured photometrically at 410 mμ. For each determination a blank was prepared by adding the material to be tested to the incubated substrate after it had been made alkaline. If necessary, enzyme solutions were diluted so as to produce optical densities less than unity.

The rate of hydrolysis is dependent on the *p*H (Fig. 2) with an optimum at *p*H 5·9–7·0. High temperature and protein precipitants inhibit hydrolysis (Table 1). These results suggest an enzymatic activity. The relationship of hydrolysis to enzyme concentration is linear; *p*-nitrophenol does not inhibit the reaction.

Apart from the possible existence of an unidentified carbohydrase[4,7], our results suggest that human amylase is able to degrade maltotriose to glucose and maltose, so that α-(*p*-nitrophenyl)maltoside may be a suitable substrate for the assay of amylase.

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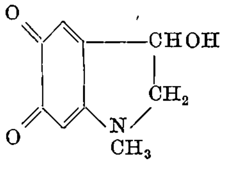
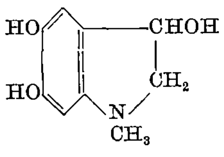
Reduction of Adrenochrome with Ascorbic Acid

The discharge of the intense red colour of aqueous solutions of adrenochrome (I) by various reducing agents has been reported by several workers[1,2]. The reaction apparently does not simply consist of the reduction of the orthoquinone moiety of the molecule with the production of the hypothetical 'leuco-adrenochrome' (2 : 3-dihydro-3 : 5 : 6-trihydroxy-N-methylindole) (II). Harley-Mason, in describing the reduction with sodium hydrosulphite or hydrogen (catalytic), postulated the initial addition of one atom of hydrogen to the molecule, with the formation of an unstable intermediate which disproportionates into (II) and a zwitterionic compound (III). The former (II) appears to be inherently unstable and readily loses water, with the formation of 5 : 6-dihydroxy-N-methylindole (IV); the second substance (III) isomerizes under the influence of alkali to adrenolutin (3 : 5 : 6-trihydroxy-N-methylindole) (V)[2,3].


(I)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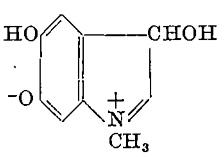
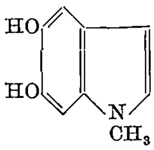
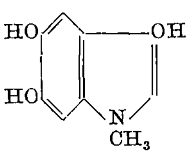

(III)


(IV)


(V)

The reduction of adrenochrome with ascorbic acid, a reaction which may have physiological significance, has been reported by Beauvillain and Sarradin[4] and by Fischer[5], who reported that this reduction product is not the same as that produced by sodium bisulphite. However, the isolation of definite reduction products was not described in either case.

We have studied the ascorbic acid-reduction products of adrenochrome, both in aqueous and methanolic solution, by paper chromatography, and the results indicate the presence of three or possibly four compounds giving chromogenic reactions characteristic of indole derivatives. All these substances also exhibited fairly marked reducing properties. The excess ascorbic acid and resulting dehydroascorbic acid were also easily detected.

Spots consisting of 10–60 μlitres of the reaction mixture (prepared from adrenochrome (0·05 gm.) and ascorbic acid (0·25 gm.) in 10 ml. solvent) were examined on Whatman No. 1 paper (previously washed with 2 per cent acetic acid) in three solvent systems: (*A*) 2 per cent acetic acid in water; (*B*) *n*-butanol/acetic acid/water (6 : 1 : 2) and (*C*) acetonitrile/acetone/water/acetic acid (80 : 5 : 15 : 1).

The chromogenic reagents employed were: (1) Ehrlich's reagent; (2) cinnamaldehyde; (3) Hopkins-Cole reagent[6]; (4) Salkowski reagent; (5) Gibbs phenol reagent; (6) diazotized *p*-nitroaniline; (7) ammoniacal silver nitrate; (8) ferric chloride-potassium ferricyanide[7]; (9) dichlorophenol-indophenol and (10) 2 : 4-dinitrophenylhydrazine.

The results obtained are given in Table 1.

In *A*, the R_F zone 0·42 ± 0·01 exhibited the characteristic colour reactions of indoles and *o*-catechols and was due to (IV). (An authentic sample of (IV) prepared from (V)[3] had the same R_F.) The zone R_F 0·83 ± 0·03 was due to dehydroascorbic acid and unchanged ascorbic acid. (Authentic specimens of these acids had R_F's of 0·86 and 0·85 respectively in this solvent; ascorbic acid gave a black spot, whereas dehydroascorbic acid gave a golden-brown spot with ammoniacal silver nitrate.) The unknown substances (VI) and (VII) with R_F values of 0·56 ± 0·02 and 0·65 ± 0·05 respectively showed modified indole reactions together with phenolic and reducing properties. In *B* (IV) had an R_F of 0·76 ± 0·02, (VI) had an R_F of 0·27 ± 0·01 and once again ascorbic acid and dehydroascorbic acid were not efficiently separated and were present in the zone R_F 0·39 ± 0·02. (Authentic samples had R_F's of 0·36 and 0·42 respectively.) In *C* (IV) had an R_F of 0·96, (VI) had an R_F of 0·55 ± 0·02 and the two acids were observed at an R_F of 0·37 ± 0·02.

Table 1. R_F VALUES OF MAJOR REACTION PRODUCTS IN VARIOUS SOLVENT SYSTEMS (see text)

*A**	*B*	*C*
0·42 ± 0·01 0·56 ± 0·02 0·65 ± 0·05 0·83 ± 0·03	0·27 ± 0·01 0·39 ± 0·02 0·76 ± 0·02	0·37 ± 0·02 0·55 ± 0·02 0·96

* In some cases, a weak spot was observed at R_F = 0·04.

In order to obtain more information about the nature of the compounds present in the reaction mixture, the individual R_F zones were eluted from the paper (larger quantities were applied in streaks to Whatman No. 3 *MM* paper and development effected with solvent *A*) and the ultra-violet spectra determined in ethanolic solution. All three zones gave similar absorption curves typical of the indole chromophore. (Zone R_F 0·42 ± 0·01: $\lambda_{\max.}$, 281; 301: $\lambda_{\min.}$, 252; 288. Zone R_F 0·56 ± 0·02: $\lambda_{\max.}$, 283; 301: $\lambda_{\min.}$, 255; 289. Zone R_F 0·65 ± 0·05: $\lambda_{\max.}$, 275; 282: $\lambda_{\min.}$, 260; 279 with shoulder at about 300 mμ.) The curve obtained from the zone R_F 0·42 ± 0·01 was identical with that of an authentic specimen of (IV).

Paper chromatographic examination of the products derived from adrenochrome by reduction with ascorbic acid, in aqueous solutions, after extraction with peroxide-free ether, indicated that the substance with R_F 0·42 ± 0·01 was removed by the ether, while all the other products remained in the aqueous phase. Crystalline 5 : 6-dihydroxy-N-methylindole (melting point 134–135° C.; melting point of diacetyl derivative 109·5–110·5° C.) was isolated from the ethereal extract.

Other reducing agents for adrenochrome not previously reported include dihydroxymaleic acid, dihydroxyfumaric acid, cysteine, and sodium borohydride (in this case, crystalline IV has been isolated from products). These studies are being continued and further details will be published elsewhere. This investigation forms part of a programme being carried out under the auspices of the Saskatchewan Committee on Schizophrenia Research and was supported by grants from the Saskatchewan Government, the Federal Department of Health and Welfare and the Rockefeller Foundation.

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Photosynthesis of Amino-Acids

It has been observed in this laboratory that when aqueous mixtures of dicarboxylic or monocarboxylic acids and certain ammonium salts are irradiated with ultra-violet light, certain amino-acids are obtained.

A cold quartz ultra-violet lamp giving 86 per cent of its output at about 2537 A. was used for irradiated mixtures of succinic, maleic, propionic and acetic acid with a number of ammonium salts. These mixtures were 0·1 molar both in organic acid and ammonium salt. The irradiation was continued in each case for 24 hr., the area of the irradiated solutions being 44 cm.^{2}, and the radiation intensity 7,500 microwatts/cm.^{2} at the surface of the liquid.

Of all the ammonium compounds investigated only ammonia and ammonium carbonate were active, and of the acids only succinic, maleic and propionic acid gave rise to amino-acids.

An absorption curve in the ultra-violet region, with a peak at 2750 A., was obtained for succinic acid irradiated in presence of ammonia or ammonium carbonate. This indicates the presence of a C=O group, which was confirmed by positive tests for aliphatic aldehyde; tests for ketone were negative. Aldehydes were not detected after irradiation of maleic and propionic acids.

The irradiated solutions were evaporated to dryness, the residue taken up with acidified acetone (in 1 per cent hydrochloric acid) for desalting, the acetone was evaporated and the residue dissolved in a few drops of *iso*propylic alcohol (10 per cent in water).

Paper chromatograms were made from these *iso*propylic solutions, using phenol saturated with water as solvent for ascending chromatography in the presence of sodium cyanide and standard solutions of amino-acids for comparison.

Table 1 gives the amino-acids detected after irradiation of organic acid – ammonium salt mixtures.

Table 1. AMINO-ACIDS DETECTED AFTER 24 HR. EXPOSURE TO ULTRA-VIOLET, λ = 2537 A.

Mixture	Amounts of amino-acids found		
	Aspartic acid	Alanine	Glycine
Succinic acid and ammonia		++	+++
Succinic acid and ammonium carbonate		++	+++
Succinic acid and ammonium thiocyanate		+	
Maleic acid and ammonium carbonate	+++	++	+
Propionic acid and ammonium carbonate			+++

Key: +++ very large, ++ large and + trace.

It must be concluded that ultra-violet, at a wavelength of 2537 A., is able to synthesize amino-acids from mixtures containing either a saturated dicarboxylic acid such as succinic acid, an unsaturated dicarboxylic acid such as maleic acid or a monocarboxylic acid such as propionic acid with carbonate or thiocyanate and ammonia.

The amino-acids are aspartic acid, alanine and glycine, that is to say, amino-acids with 4, 3 and 2 carbon atoms respectively.

Only succinic acid gives an aliphatic aldehyde after irradiation.

A browning reaction occurs during the evaporation of the irradiated solutions, the intensity of which is dependent on the nature of the organic acid.

A full description of the results obtained in this field will be published later.

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A Colorimetric Test for Gibberellic Acid and Evidence from a Dwarf Pea Assay for the Occurrence of a Gibberellin-like Substance in Wheat Seedlings

A RECENT communication by McComb and Carr[1], reporting the use of a dwarf pea bioassay for naturally occurring gibberellins, prompts this report of some results of an experiment designed to investigate whether gibberellic acid occurs naturally in etiolated wheat seedlings.

Wheat (var. Eclipse) was grown in darkness for four days at 25° C. on moist filter paper contained in 11-cm. Petri dishes. In all, 12,500 coleoptiles with enclosed primary leaves were excised at 96 hr.; these were cut transversely into halves, representing the basal region, including the leaf meristem (135 gm. fresh weight), and the tip (205 gm. fresh weight). Basal and tip sections were frozen separately to − 15° C. in 2·5 l. of phosphate/citrate buffer of *p*H 3·8 and, after thawing, the tissue was filtered. Peroxide-free ether (3·3 l.) was passed over the tissue and shaken with the filtrate in five aliquots. The resulting ether fraction was extracted with 4·4 l. of 1 per cent sodium bicarbonate in five aliquots. This solution was then acidified to *p*H 3·0 with sulphuric acid and extracted five times with a total of 3·3 l. of peroxide-free ether.

Each of the two acidic and neutral fractions was reduced to small volume and transferred, as a series of spots on the starting line, to 25·5 cm. square Whatman No. 1 chromatography papers. Four sheets were used for each fraction. The chromatograms were developed by ascending chromatography, using the solvent system *iso*propanol/ammonia (0·880)/water (10 : 1 : 1), the papers being removed when the solvent front had moved 23 cm. Each sheet was cut horizontally into nine strips each 2·5 cm. wide; these strips were then eluted with acetone, which in each case was concentrated to 2·5 ml. The thirty-six eluates were each transferred to 25·5 cm. square Whatman No. 1 chromatography papers as a single spot for development in two directions in the solvent systems, (*a*) *iso*propanol/ammonia (0·880)/water (10 : 1 : 1); (*b*) *n*-butanol/ammonia (0·880)/water (200 : 6 : 36). In each case the solvent was allowed to move 23 cm. Papers were dried between development in a current of air. Finally the papers were sprayed with Folin and Ciocalteau's[2] reagent and kept in darkness for 4 hr. at 25° C. I find that this reagent gives a characteristic colour with gibberellic acid.

When gibberellic acid, melting point 232–233·5° C. (decomposition), supplied by Imperial Chemical Industries, Ltd., was resolved in each of the above solvent systems and the chromatograms sprayed with this reagent two bright blue spots appeared as follows: (1) a dense blue spot, R_F value 0·52 in system (*a*) and 0·24 in system (*b*); the material extracted from this position on the unsprayed paper was found to induce a growth response in dwarf pea plants as described below. (2) a small blue spot, R_F value of 0·04 in system (*a*) and 0·00 in system (*b*); this material from the unsprayed paper was found not to induce a growth response in the dwarf pea test. The lower limit of detection on a two-way chromatogram using this colorimetric test is about 5 μgm.

None of the chromatograms from the tissue extracts described here showed a positive colour response with the reagent. In order to detect the possible presence of gibberellic acid in quantities less than 5 μgm., a bioassay was carried out using dwarf pea seedlings. Dwarf peas (var. Meteor) were planted in moist sand, four in each 14-cm. pot, and grown for seven days under glasshouse conditions. Pots showing uniform growth were selected for treatment. When one drop of a solution of gibberellic acid (1–5 μgm.) in 10 per cent aqueous acetone was applied to the growing tips of such plants a considerable stimulation to growth was observed. This increase over control growth could be readily assessed. The acetone eluates from the different segments of the chromatograms obtained from the plant extracts, each representing a specific zone on the paper, were examined in this test. One drop (about 0·05 ml.) of the acetone solution added to 0·5 ml. of water was applied to the tips of four plants. Measurements of the total height of the plants were taken ten days after the treatment. Results for the acidic fractions are summarized in Fig. 1.

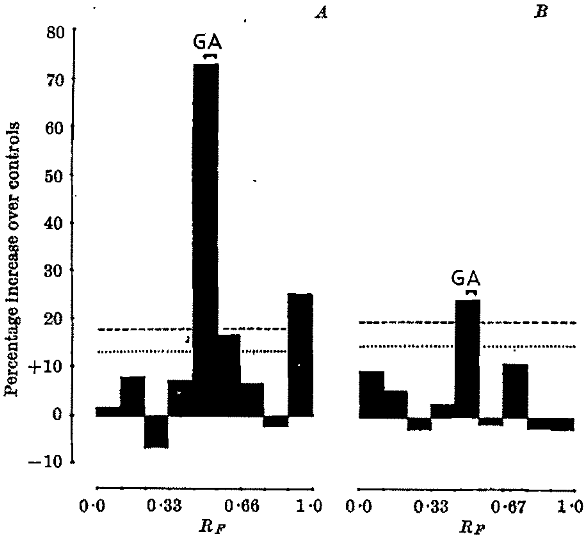

Fig. 1. Bioassay of extracts from wheat seedlings. The growth of dwarf Meteor peas is expressed as percentage increment over control. The increment for control plants treated with 1 μgm. per plant of gibberellic acid (G.A.) is 470. *A*, Extract from basal portion of wheat seedling shoots; *B*, extract from tips of wheat seedling shoots. Significant difference from control: – – –, (P = 0·01); . . . ., (P = 0·05)

It will be noted that a highly significant activity was found in the extract obtained from the basal region of wheat seedlings and that some activity was found in the extract from the tips of seedling shoots. Furthermore, the activity observed from the wheat extracts is seen to be associated with the gibberellic acid area of the chromatogram. In addition, there is an area of activity at, or near, the solvent front in the extract from the basal portion of the wheat seedling shoot.

Since the growth response corresponding to the region R_F 0·44–0·56 of the wheat seedling chromatograms was very considerably less than that obtained with 1 μgm. of gibberellic acid, it is not surprising these chromatograms gave a negative test with the Folin and Ciocalteau's reagent. The results presented here, however, provide evidence that gibberellin-like materials occur naturally within the tissues of wheat seedlings.

Advice and assistance from Prof. R. L. Wain are gratefully acknowledged.

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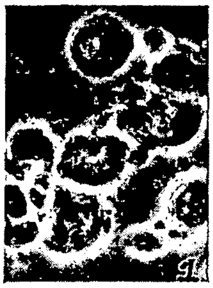
Possible Use of Synthetic Surface-active Agents for the Preparation of Tumour Cell Nuclei

WHILE the observation has been made that surface-active agents will produce lysis of the plasma membrane of cells[1, 2], little use seems to have been made of this observation for the preparation of nuclei[3]. Some preliminary observations suggest that nuclei may be prepared in large numbers from a variety of cells, without the use of special apparatus, by treatment with the anionic surface-active agent, sodium lauryl sulphate. Nuclei prepared in this manner are at least as free from cytoplasm as those prepared by the method of Hogeboom *et al.*[4]. In the case of some tumours, such as the *V*–2 carcinoma of the rabbit, they are very much cleaner (Figs. 1 and 2).

Suspensions of tumour cells have been prepared from frozen and fresh tumour by light grinding in a porcelain mortar in 5 volumes of 0·15 *M* saline. The suspensions were filtered successively through No. 80 gauze and 80- and 120-mesh wire screens. The tumour cell suspensions were stirred on ice and 0·4 per cent sodium lauryl sulphate, at room temperature, in 0·15 *M* saline (*p*H 6·9) added. Small drops were removed periodically for observation by phase-contrast microscopy. At concentrations of the surface-active agent of approximately 15 to 20 × 10^{-4} *M* most of the nuclei were free from cytoplasm. Small wisps may adhere to some nuclei when certain tumours are treated. When an optimum freeing of nuclei has been observed, these may be recovered by centrifugation and washing in 0·15 *M* saline. Similar results may be obtained by substituting 0·25 *M* sucrose for the 0·15 *M* sodium chloride.



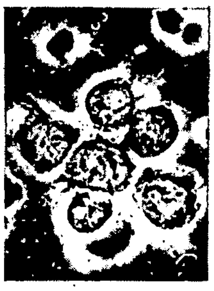


Fig. 1. Fragmented cells of *V*–2 rabbit carcinoma after treatment in glass tube homogenizer with 'Teflon' pestle; method of Hogeboom *et al.* (ref. 4). (× 500)

Fig. 2. Crude preparation of nuclei of *V*–2 carcinoma cells. Prepared in saline and sodium lauryl sulphate. (× 500)

Lysis of cells of *V*–2 carcinoma of the rabbit seems to proceed in several steps: swelling of cytoplasm, rupture of the cell membrane, fragmentation of the cytoplasm, freeing of the nuclei, and finally extraction of the nuclear nucleoprotein. This latter step occurs at a concentration of approximately 31×10^{-4} *M* (ref. 5), and results in nuclear ghosts. The nuclei so prepared meet the criteria of Philpot and Stanier[6], namely, intact membranes without blebs, no clumping, intact nucleoli, normal granularity, and extractability of highly polymerized deoxyribonucleic acid. It is realized that morphological criteria may not be sufficient indications of the functional integrity of the nuclei. Biological experiments attempting to elucidate this point are under way. So far most work has been with the *V*–2 carcinoma, but nuclei have also been prepared from the Ehrlich ascites tumour, spontaneous mammary carcinoma of the mouse, and mouse lymphoma.

Experiments with the cationic detergent cetyl trimethylammonium bromide and the non-ionics 'Tween 80' and 'Triton *X*-102' have resulted in cytolysis but have not caused freeing of the nuclei. The non-ionic 'Triton *X*–45' and anionics sodium 2,4- and 2,5-dimethylbenzene sulphonate have occasionally caused the appearance of free nuclei, but not in sufficient number for preparative purposes. Experiments are in progress utilizing other anionic detergents containing the sulphate group and with non-ionic and cationic agents containing a lauryl side-chain.

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Effect of the Borate Ion in Buffers on the Electrophoresis of Rat Serum

It has recently been reported that the electrophoretic mobility of certain protein components of human[1,2], bovine and rat[3] sera are altered in buffers containing borate. A more extensive investigation of the effect of borate buffers has been carried out in this laboratory during the past two years, during work on the transport of vitamin A alcohol in rat serum (Garbers, C. F., Gillman, H., and Peisach, M., unpublished work). These results are briefly recorded here.

A borate–phosphate buffer, *p*H 8·6 and $I = 0{\cdot}05$, was used for the preparative electrophoretic separation of rat serum proteins on partially acetylated cellulose powder columns[4,5]. A protein component migrating faster than the albumin during electrophoresis was observed (Fig. 1). Fractions 6–18, forming the albumin peak were analysed in the analytical ultracentrifuge ('Spinco' Model *E*). The albumin peak consisted of at least three components, namely, albumin, macroglobulin and the third component which migrated faster than the albumin on electrophoresis. This component possessed the sedimentation properties of a globulin (Fig. 2), stained positive for a glycoprotein[6] and, on paper electrophoresis in the veronal buffer had a mobility slightly lower than the albumin. When the non-complexing veronal buffer, *p*H 8·6 and $I = 0{\cdot}05$, was used for the preparative electrophoretic separation, this glycoprotein component did not migrate in front of the albumin, although the position of the macroglobulin was unaltered.

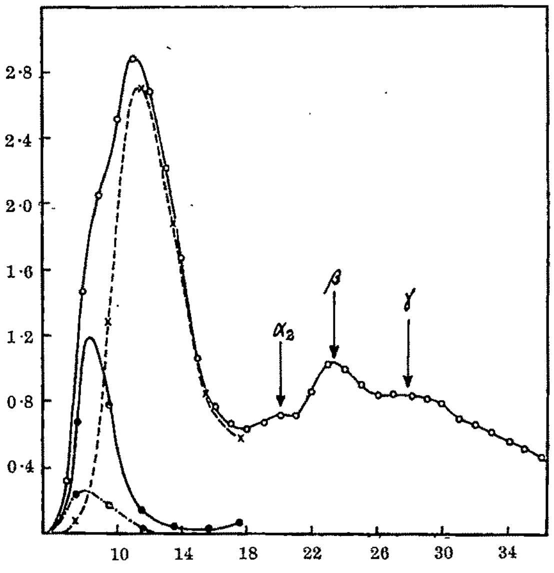
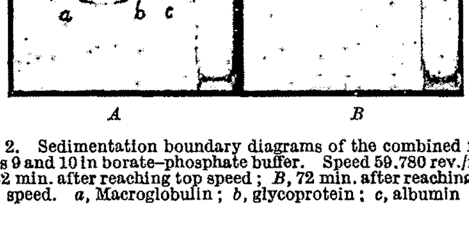


Fig. 1. Eluate from electrophoretic separation on a cellulose powder column (2 × 32 cm.) of rat serum proteins (3 ml.) using the borate–phosphate buffer, *p*H 8·6, *I* 0·05. —O—O—, total protein; —×—×—, albumin; —●—●—, α_1-glycoprotein; –.–●–.–●–.–, macroglobulin

Investigation of this phenomenon by paper electrophoretic techniques established that, in the rat, most of the mucopolysaccharides are associated with the α_1-globulin. In the complexing borate buffer this α_1-glycoprotein component acquires a mobility which



A *B*

Fig. 2. Sedimentation boundary diagrams of the combined fractions 9 and 10 in borate–phosphate buffer. Speed 59.780 rev./min. *A*, 32 min. after reaching top speed; *B*, 72 min. after reaching top speed. *a*, Macroglobulin; *b*, glycoprotein; *c*, albumin

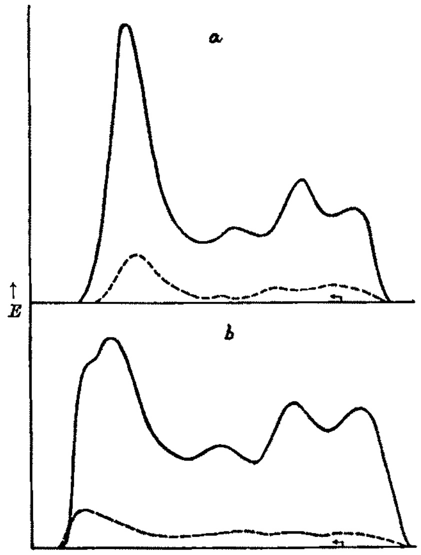


Fig. 3. Diagrams obtained after the electrophoresis of rat serum at *p*H 8·6, *I* 0·05. *a*, Veronal buffer; *b*, borate-phosphate buffer. ——, Stained for proteins (bromophenol blue); – – –, stained for glycoproteins

is greater than that of the albumin, whereas in the non-complexing veronal buffer its mobility is less than that of the albumin (Fig. 3).

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Formation of Activated Amino-Acids by Intact Cells of *Azotobacter vinelandii*

It has been shown[1-4] that various preparations of enzymes which activate amino-acids convert them into a form which is adsorbed on charcoal, is unstable to alkali, and which reacts with hydroxylamine to form amino-acid hydroxamates. These 'activated' amino-acids seem to be amino-acid-polynucleotide compounds[1-4], and have been suggested[4] as intermediates in protein synthesis, because the amino-acid of such compounds is incorporated into the protein of isolated microsomes. Activated amino-acids have been formed only in cell-free preparations, and it is of considerable interest to determine whether similar compounds are formed by intact cells.

Cells of *Azotobacter vinelandii* were suspended in 0·1 *M tris*-(hydroxymethyl)-aminomethane buffer (*p*H 7·25) containing 0·5 μc. of glycine or leucine labelled with carbon-14. After varying periods of time, the temperature of the suspension was reduced to 1° C., and the cells were broken by sonic vibration. Cellular debris was removed by centrifuging at 30,000*g*. Protein was precipitated from the supernatant solution with 6 per cent perchloric acid and isolated as described previously[5]. 1 gm. of charcoal was stirred into each 10 ml. of the perchloric acid extract. The charcoal was collected by centrifugation, washed twice with 0·05 *M* potassium phosphate, and twice with 0·1 *M* potassium acetate. Control experiments demonstrated that this washing removes all free glycine or free leucine from the charcoal. The charcoal, however, contains considerable amounts of bound glycine or leucine. If the charcoal is extracted with 0·2 *M* hydroxylamine, the glycine or leucine is removed as glycine- or leucine-hydroxamate. These substances migrate on paper chromatography along with authentic samples of the respective hydroxamates. The amino-acids, therefore, are apparently bound by their carboxyl groups to some substance which is adsorbed by charcoal. At 25° C., the 'amino-acid-*X*' is stable for at least 6 hr. at *p*H 7, but is degraded, with the liberation of free glycine, at higher *p*H values. For example, it has a half-life of about 60 min. at *p*H 8, and of 20 min. at *p*H 9. The amino-acids are not bound as an artefact due to sonic vibration, as cells disrupted by an osmotic technique[6] also contain glycine adsorbable on charcoal.

Table 1. Incorporation of Glycine labelled with Carbon-14 into Protein and Glycine-*X* of *Azotobacter vinelandii*

Time (sec.)	Counts per min. per mgm.	
	Glycine-*X*	Protein
0	0	0
5	205	0
15	278	0
30	305	9
120	318	28
300	413	117
900	505	311
3,600	486	3,300
900 (plus 6×10^{-4} *M* chloramphenicol)	710	180
900 (plus 10^{-3} *M* cobalt ions)	550	215

Table 1 presents the time course of incorporation of glycine labelled with carbon-14 into protein and into the charcoal-adsorbable fraction of *Azotobacter* cells. Detectable amounts of labelled glycine cannot be found in protein until at least 30 sec. after the cells have been placed in the labelled glycine solution. In contrast, the fraction adsorbable on charcoal has incorporated considerable amounts of glycine within 5 sec. Table 1 also shows that both chloramphenicol and cobalt ions, which are inhibitors of protein synthesis, enhance slightly the incorporation of glycine into 'glycine-*X*'.

The various properties of this material resemble the properties of the activated amino-acids reported by other investigators, and suggest that intact cells incorporate amino-acids into some activated form which is at least similar to that obtained in cell-free preparations. The activated glycine obtained from *Azotobacter* cells does, however, differ from other preparations in that it is not precipitated by ethanol from a phenol extract by the method of Kirby[7]. It may be that the amino-acids are not bound to polynucleotide in intact cells, or they may be bound to a rather small polynucleotide. Determination of the exact nature of these amino-acid compounds and their relationship, if any, to cellular protein synthesis requires further investigation.

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Formation of Phosphoserine from 3-Phosphoglycerate in Higher Plants

STUDIES with carbon-14 dioxide in plants have indicated that serine may be formed from glycine[1,2], and previous results from this laboratory[3] have shown that serine and glycine are interconvertible in plant tissues. However, other studies[4,5] have indicated that serine may be formed before glycine, and this communication presents evidence that serine may be formed *via* phosphoserine from phosphoglycerate, a pathway previously demonstrated in animals[6].

D-3-Phosphoglycerate-^{32}P was prepared by a modification of the method of Neuberg and Lustig[7]. The purity of the compound was established by chromatography and the chromatographically pure compound was eluted from the paper. The enzyme system was prepared from 8–10 day old pea epicotyls (110 gm.) grown in the dark, by grinding with sand and phosphate buffer (0·2 *M*, *p*H 7·4, 200 ml.). The homogenate produced was strained through linen and centrifuged until it was clear. Solid ammonium sulphate was added to 80 per cent saturation, and the suspension was centrifuged at 30,000*g* for 10 min. The precipitate was dissolved in 10 ml. of the above buffer and dialysed against 2 l. of 0·05 *M* phosphate buffer (*p*H 7·4). All operations were carried out at 2°.

The enzyme (1·0 ml.) was incubated with D-3-phosphoglycerate-^{32}P (5 μmoles), diphosphopyridine nucleotide (3 mgm.), L-glutamate (25 μmoles), pyridoxal phosphate (0·05 μmole), and phosphate buffer (1·0 ml., 0·2 *M*, *p*H 7·4), in a total volume of 2·5 ml. for 2 hr. at 37° C. The reaction was stopped by addition of absolute ethanol to a final concentration of 50 per cent, and the precipitated protein was spun down and discarded. A control experiment in which the reaction was stopped at zero time was included.

Table 1. SYNTHESIS OF PHOSPHOSERINE-^{32}P FROM PHOSPHOGLYCERATE-^{32}P

Experiment	Phosphoglycerate-^{32}P	Phosphoserine-^{32}P	Unidentified (*C*) (phosphoserine-^{32}P)
Zero time (c.p.m.)	10,900	0	0
2 hours (c.p.m.)	8,400	670	190
2 hours (percentage initial phosphoglycerate-^{32}P)	77	6	1·7

Incubation as in text. Radioactivity measurements corrected for decay.

1·5 ml. of the resulting solutions were applied as streaks to paper chromatograms which were run in ethyl ether, formic acid (60 : 40) at 2°. Autoradiographs of these chromatograms showed that a compound with the same R_F as phosphoserine was formed after incubation but was absent at zero time. This compound was eluted, carrier phosphoserine added, and placed as a spot on a paper chromatogram which was run in phenol saturated with water–formic acid (96 : 4). Phosphoserine was detected by spraying with ninhydrin, and the radioactivity found to coincide with this area (*A*, Fig. 1). Marker spots of phosphoserine were placed on the paper and similarly sprayed with ninhydrin. The action of ninhydrin on phosphoserine produces phosphoglycolaldehyde. The paper was then run in the other direction with *t*-butanol, water, picric acid (80 : 20 : 2 v/v/w). An autoradiograph showed the presence of two radioactive compounds. The compound with the lower R_F (*B*, Fig. 1) had the same R_F (0·5) as the marker phosphoglycolaldehyde, formed from carrier phosphoserine and was found to coincide exactly with the radioactive area. The faster running radioactive compound (*C*, Fig. 1) has not been identified, but

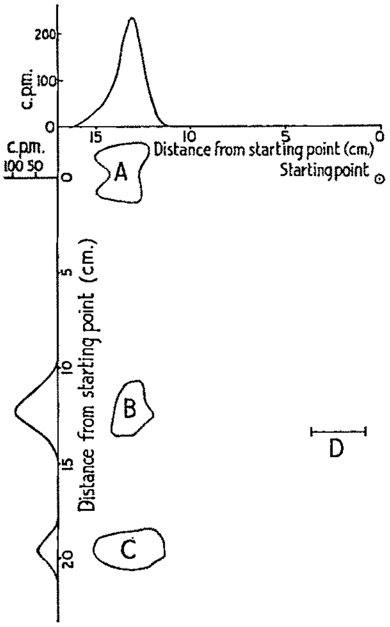

Fig. 1. Identification of phosphoserine-^{32}P formed from D-3-phosphoglycerate-^{32}P. *A*, Phosphoserine-^{32}P; *B*, phosphoglycolaldehyde-^{32}P; *C*, unidentified; *D*, R_F of phosphoglycolaldehyde. Chromatogram run in: horizontal, phenol saturated with water–formic acid (96 : 4); vertical, *t*-butanol, water, picric acid (80 : 20 : 2 v/v/w).

may be an isomer of phosphoglycolaldehyde[8]. The quantitative yield of phosphoserine is shown in Table 1.

The individual reactions involved in the synthesis of phosphoserine :

$$\text{D-3-Phosphoglycerate} + \text{DPN}^{+} \rightleftharpoons \text{phosphohydroxypyruvate} + \text{DPNH} + \text{H}^{+}$$

$$\text{Phosphohydroxypyruvate} + \text{L-glutamate} \rightleftharpoons \text{phosphoserine} + \alpha\text{-oxo-glutarate}$$

have been demonstrated, and the specificity and properties of the enzymes are under investigation.

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Effect of Copper on Growth and Catalase Levels of *Corcyra cephalonica* St. in Zinc Toxicity

THE work of Smith and Larson[1], van Reen[2] and van Reen and Pearson[3] has revealed that the dietary ingestion of toxic levels of zinc results in a marked inhibition of growth and deranged iron metabolism in rats. The latter effect was reflected in anæmia and decreased levels of liver catalase and cytochrome oxidase. Liver extract partially counteracted the growth inhibition, while minute supplements of copper to the toxic diet reversed the anæmic condition[1] and restored the levels of the iron enzymes[2]. From such results it has been concluded that the inhibition of growth is unrelated to the enzymic changes observed, and that the two phenomena are distinct and different effects of zinc toxicity in the animal organism.

In view of our earlier studies on zinc toxicity in the larvæ of the rice moth, *Corcyra cephalonica* St.[4], it was thought of interest to investigate the zinc–copper relationship from this point of view. For this purpose, groups of 10–15 day-old larvæ, weighing between 7·0 and 9·0 mgm. per ten, were grown for a period of three weeks on the following diets : (1) control, basic diet of sieved wheat flour ; (2) zinc toxic-basal diet plus 0·4 per cent $ZnSO_4,7H_2O$; (3) zinc toxic diet as in (2) with graded amounts of $CuSO_4,5H_2O$; and (4) zinc toxic diet supplemented with 1·0 per cent liver extract. The last group, namely, that with liver extract, was included for purposes of comparison with earlier work[1–4]. The experimental procedure involved in the preparation of the liver extract and the rearing of the larvæ has been described in detail elsewhere[4]. Growth was recorded at weekly intervals. At the end of three weeks, larvæ from each group were weighed and homogenized in $M/15$ phosphate buffer (pH 7·0). Catalase activity was determined by allowing aliquots of the buffer extract to act upon 0·05 M hydrogen peroxide and titrating the unreacted hydrogen peroxide, at the end of the reaction period, with $N/100$ potassium permanganate, according to the procedure of Ramachandran and Sarma[5]. Catalase activity was expressed as ml. of $N/100$ permanganate consumed per gm. of larval tissue per minute. The results obtained in a typical experiment are shown in Table 1.

Table 1. INFLUENCE OF COPPER ON ZINC TOXICITY IN RICE MOTH LARVÆ

No.	Supplements to basal diet (10 gm. sieved wheat flour)*	Weight of 10 larvæ (mgm.)				Catalase units
		At transfer	1st week	2nd week	3rd week	
1	Control (no zinc)	7·7	38	105	226	493·2
2	None	8·3	22	57	100	309·1
3	0·005 per cent copper sulphate	7·0	23	56	103	393·6
4	0·01 per cent copper sulphate	8·2	22	59	98	540·6
5	1·0 per cent liver extract	6·0	31	94	194	315·5

* Unless otherwise stated, all diets also contained 0·4 per cent zinc sulphate.

It can be seen that the intake of toxic amounts of zinc brings about not only an inhibition of growth but also a pronounced fall in tissue catalase activity. 0·01 per cent copper sulphate, added to the zinc-toxic diet, restores the enzyme levels without, however, improving growth to any extent. Sivarama Sastry, Radhakrishnamurty and Sarma[4] have recently shown that this growth inhibition can be considerably reversed by the inclusion of liver extract in the toxic diet. The results presented in Table 1 show that liver extract has little effect on catalase activity, however.

These results indicate that the inhibition of growth and in catalase activity are separate effects of zinc toxicity in the insect organism, as in the rat[1,2], and point to the probable multiplicity of metabolic disturbances involved in zinc toxicosis. Since it is well known that catalase level in animal tissues is decreased by either an iron or copper deficiency[6] and that copper influences iron metabolism[7], it is likely that the antagonistic behaviour of zinc and copper brought out by the present investigation is a reflexion of an adverse effect of zinc on iron metabolism in the larvæ. It is also possible that such an interference with iron metabolism is a common phenomenon in zinc toxicosis.

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Effect of Nicotinic Acid on the Cholesterol Contents of Rat-Livers

LOWERING of the blood cholesterol level by means of large doses of nicotinic acid has been described by Altschul[1], and this effect has been confirmed by others[2]. This effect is caused by nicotinic acid only and its mechanism has not yet been clarified. The use of the amide of the nicotinic acid is said to be without effect.

Table 1

Percentage nicotinic acid in diet	No. of rats	Liver content: Total cholesterol (mgm. per cent)	P	Total lipids (per cent fresh weight)
0	8	1,181·5		25·0
1	10	1,038·3	$< 0·5$	30·8
2	10	923·3	$< 0·2$	31·0
3	10	683·7	$< 0·01$	24·4
4	10	634·1	$< 0·01$	25·2
Normal diet (*C*)	10	220·0		5·0

50 Sprague–Dawley rats (male), ranging in weight from 110 to 120 gm., were fed for 21 days on a special hypolipotropic diet free from cholesterol. This caused an endogenous fatty liver of the cholesterol type (group *A*) (unpublished work). Another group received the same diet but with nicotinic acid in increasing amounts, namely, 1, 2, 3 and 4 per cent (group *B*). A third group (*C*) was fed a normal diet. All animals were killed at the end of this experiment under light ether anæsthesia; after exsanguination the livers were processed according to Sperry's method, and total lipid[3] and cholesterol contents were determined. The results are given in Table 1. Increased cholesterol contents were found in the livers of the animals fed the special diet, the content in group *A* (without nicotinic acid) being six times as great as that in group *C* (normal diet). Liver cholesterol decreased with increasing nicotinic acid in the special diet, but 4 per cent nicotinic acid did not reduce the cholesterol level to its normal value. Nicotinic acid, *per se*, tends to produce fatty degeneration of the liver[4] and intolerably large doses may be necessary to bring the liver cholesterol produced by the special diet to its normal level.

This antilipotropic effect of nicotinic acid can be interpreted as due to the demand of its detoxication products for methyl groups. Detoxication may occur via nicotinic acid, which needs coenzyme A for synthesis. It is suggested, therefore, that this effect is caused by infiltrative fattening of the liver and reduced synthesis of cholesterol (relative lack of coenzyme A).

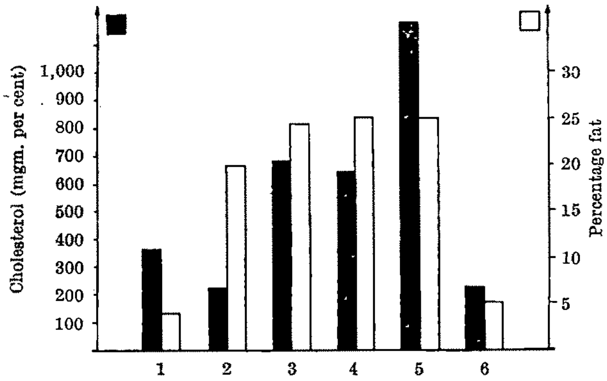

Fig. 1. Cholesterol and fat contents of rat livers after feeding the special diet with (1) 2 per cent α-phenylbutyric acid, (2) 2 per cent α-diphenylylbutyric acid, (3) 3 per cent nicotinic acid, (4) 4 per cent nicotinic acid, (5) control group *A*, (6) normal diet, group *C*

Altschul[1] explained the lowering of the level of cholesterol in the blood by nicotinic acid as due to increased oxidative catabolism of cholesterol. Merill[5], working with rabbits, has suggested possible detoxication products of nicotinic acid, but his work has not afforded clear proof of the inhibition of acetylation *in vivo*. Recent investigations *in vitro* have demonstrated inhibition of acetylation[6], but such experiments *in vitro* cannot establish the influence of nicotinic acid on synthesis of cholesterol.

Comparison investigations using α-phenylbutyric acid and α-diphenylylbutyric acid has led to the following suggestions (Fig. 1): (1) that synthesis of cholesterol is decreased by the influence of nicotinic acid, and (2) that a relative lack of coenzyme A is the causative mechanism.

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Effect of Splenectomy on the Phagocytic Activity of the Reticulo-Endothelial System

THE reticulo-endothelial system comprises groups of cells situated in various parts of the body having the ability to take up particulate and colloidal matter. The cells of this system, which have an intimate relationship with the circulation, are to be found mainly in the liver and spleen, from which organs about 95 per cent of intravenously injected particulate material may be recovered[1] and of this amount we have found in mice that the spleen contains less than 5 per cent.

It is generally recognized that the macrophages of the splenic sinusoids play an important part in various physiological and pathological processes. It has been shown by Nicol *et al.*[2] that prolonged œstrogenic stimulation appeared not only to produce a greater formation and activation of reticulo-endothelial cells in the spleen but also assisted their mobilization and liberation into the circulation. This might, therefore, suggest that the importance of the spleen in phagocytic activity is not adequately reflected by the small amount of injected particulate or colloidal matter which is to be found in that organ. The present investigations were planned to ascertain the effect of splenectomy on the rate of removal of particulate matter from the circulating blood.

The following experiments were carried out on 70 male white mice (*T.O.* Swiss strain) of 20–25 gm. body-weight. The phagocytic activity was measured by the rate of disappearance of a known amount of carbon from the circulating blood, as described in a recent communication[3]. The total body phagocytic activity or phagocytic index is denoted as previously by the symbol *K*.

Twenty-five of the animals were used as controls. They were given carbon only and showed an average phagocytic index or *K* value of 26 ± 4·8. The remainder of the animals were divided into two groups and treated as follows. Group I: Twenty-seven mice were splenectomized, the spleen being removed through a left subcostal incision under open-ether anæsthesia. The incision was closed in two layers using fine silk. The animals made an uneventful recovery and appeared to be little affected by the operative procedure. Group II: Eighteen animals were subjected to a left subcostal incision, the spleen being examined but not removed and the wound being closed as in Group I.

In both groups the phagocytic index was then assessed for batches of three animals at varying times from 6 hr. to 8 days after the operation. The results are shown in Table 1. It can be seen that, in the splenectomized animals, 6 hr. after the operation there is marked depression of phagocytic activity, the phagocytic index being reduced to $K = 8$, and that recovery to within normal limits occurs in about 4 days. In the animals subjected to a similar operation in which the spleen was not removed (mock splenectomy) the phagocytic activity also becomes depressed after 6 hr. but to a lesser extent than in the splenectomized animals, and recovery to normal limits takes about 7 days.

Table 1. EFFECT OF SPLENECTOMY AND 'MOCK SPLENECTOMY' ON THE PHAGOCYTIC ACTIVITY OF THE RETICULO-ENDOTHELIAL SYSTEM

Time following operation	Phagocytic index (*K* value)	
	Group I Splenectomized animals	Group II 'Mock splenectomized' animals
6 hr.	8	13
1 day	10	10
2 days	13	
3 days	12	12
4 days	20	12
5 days	23	
6 days	25	16
7 days	29	23
8 days	22	

Phagocytic index for 25 control animals not undergoing operation, 26 ± 4·8.

The results show that after splenectomy there is marked depression of phagocytic activity for about 4 days and this appears to be chiefly the effect of the anæsthetic and operative procedure. The speedier recovery of phagocytic activity in the splenectomized animals to within normal limits is probably due to the compensatory action of the liver, but experiments of several months duration may be necessary to confirm this.

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Infectivity of Ribonucleic Acid from Mice and Tissue Culture infected with the Virus of Foot-and-Mouth Disease

SEVERAL workers[1-5] have recently reported the preparation of infective ribonucleic acid from tissues or tissue cultures infected with animal viruses, using the phenol method described by Gierer and Schramm[6] for tobacco mosaic virus. In this laboratory, ribonucleic acid prepared by the same method from pig kidney tissue cultures infected with the virus of foot-and-mouth disease (strain 997—Waldmann type *C*) has been shown (*a*) to induce cytopathic effects in pig kidney cell monolayer cultures, (*b*) to paralyse and ultimately kill unweaned mice if administered intramuscularly, and (*c*) to yield in tissue culture and in mice virus of the same immunological type as the original strain (complement fixation and serum neutralization tests).

Although direct evidence is still lacking, the following observations are regarded as pointing to the absence of residual virus from the preparations. Treatment of the preparations either with ribonuclease (at a concentration of 10 μgm./ml.) or with normal guinea pig serum abolishes their infectivity for mice and for tissue cultures, whereas the virus is unaffected by these treatments. None of the ribonucleic acid preparations so far examined has been infective when inoculated intraperitoneally into mice although the virus is highly infective when inoculated by this route. Skinner, at this Institute, has shown that intramuscular inoculation of virus into unweaned mice gives an end point higher than that obtained by intraperitoneal inoculation. For strain 997 we have found in three experiments that this difference is about 0·4–0·7 log unit, comparable with that found by Skinner for some other strains. This difference would at first suggest that the infectivity of the ribonucleic acid (inoculated intramuscularly) might be due to residual virus which would not be detected by the intraperitoneal route, since in general the ribonucleic acid prepared from pig kidney tissue culture fluids with a virus titre of $10^{4\cdot5}$ *ID*50 0·03 ml. (intraperitoneal inoculation of unweaned mice) had a 50 per cent end point dilution of $10^{-0\cdot5}$ (intramuscular inoculation). That this is not so is indicated by the following experiments. A concentrate of pig kidney tissue culture fluid prepared by precipitation with ammonium sulphate which contained $10^{6\cdot0}$ *ID*50 0·03 ml. (intraperitoneal inoculation of unweaned mice) and $10^{8\cdot3}$ *ID*50 ml. (titration in pig kidney cell monolayers) gave a ribonucleic acid preparation which was non-infective intraperitoneally but killed mice at a dilution of 1/10 inoculated intramuscularly and infected pig kidney cell monolayer cultures at a dilution of 1/100. In another typical experiment 0·3 ml. of the ribonucleic acid failed to infect any of 10 mice inoculated intraperitoneally whereas 0·03 ml. of the same preparation killed all of 10 mice inoculated by the intramuscular route.

Infection of the kidney cells and the mice with ribonucleic acid led to the production of apparently complete virus. This virus was neutralized by type specific guinea pig antiserum but not by normal serum.

Some experiments have also been done with a neurotropic strain of the virus[7,8]. This virus, which is type *A* (complement fixation test), regularly infects adult mice when inoculated intracerebrally. The ribonucleic acid prepared from the brains of such infected mice was infective for mice by the intracerebral route. If the ribonucleic acid preparation was first treated with ribonuclease it was non-infective. The harvested brains from the animals infected with the ribonucleic acid preparation were fully infective for mice by intracerebral inoculation and fixed complement with type *A* guinea pig antiserum.

We wish to thank Mr. H. H. Skinner for carrying out some of the experiments with the neurotropic strain and Dr. F. K. Sanders for discussions and many helpful suggestions.

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Change in Oxygen Consumption of the New-Born Pig with a Fall in Environmental Temperature

THE oxygen consumption of the new-born pig during the first day of life increases[1] to the extent of approximately 1 ml. oxygen/kgm.min. per 1° C. fall in environmental temperature over the range 38–20° C. The mean level of oxygen consumption rises between the first and second days, and the inverse relation between metabolism and temperature is maintained[2]. It is therefore of interest that Holub, Forman and Ježková have reported[3] the absence of an increase in the metabolism of pigs from three to six days of age when the environmental temperature is lowered from 23° to 3° C. Observations have now been made on an experimental pattern similar to that adopted by those authors on pigs from birth to six days of age. The results obtained fail to confirm those of Holub *et al.*; indeed, there was a marked rise in oxygen consumption in every case when the temperature of the surroundings fell from near 23° C. to approximately 3° C.

18 Large White pigs, of both sexes and taken from six litters, were used in these experiments; six were less than 1 day old, including two which had not been suckled by the sow (weight range: 1·07–1·40 kgm.), six were 2–4 days old (weight range: 1·15–1·72 kgm.) and six were 5–6 days old (weight range: 1·56–2·72 kgm.). They were born in a farrowing house (general air temperature: 7–15° C.) fitted with creeps heated by infra-red lamps. Consumption of oxygen at both environmental temperatures was measured by spirometer, in a closed circuit system with continuous removal of carbon dioxide. The consumption was measured for individual pigs first in the region of 23° C., then at 3° C., then again at 23° C. Measurement periods were never less than 30 min., and were always preceded by an equilibration period of 10–15 min. in either chamber. Omission of an adequate equilibration period gave spuriously low figures for the consumption of oxygen, due to the unreliability of readings of air temperature taken within the first few minutes after the closing of the chamber. Rectal temperatures were recorded four times for each pig, that is, before each measurement period and at the end of the experiment.

Table 1. OXYGEN CONSUMPTION OF NEW-BORN PIGS IN THE FIRST WEEK OF LIFE AT ENVIRONMENTAL TEMPERATURES OF APPROXIMATELY 23° AND 3° C. SIX PIGS IN EACH AGE GROUP

Age	Environmental temperature (°C.) Mean ± S.E.	Oxygen consumption (ml. dry gas at S.T.P./kgm. min.) Mean ± S.E.
Under 1 day	22·8 ± 0·4 3·1 ± 0·1 22·2 ± 0·1	21·6 ± 1·1 34·5 ± 1·1 24·9 ± 1·0
2–4 days	23·3 ± 0·9 3·8 ± 0·9 23·0 ± 0·2	25·7 ± 0·9 38·8 ± 0·9 26·0 ± 0·6
5–6 days	24·1 ± 0·6 5·0 ± 0·5 23·6 ± 0·5	22·7 ± 0·6 35·9 ± 1·2 22·9 ± 1·0

In every case the consumption of oxygen was considerably greater at 3° than at 23° C.; contrary to the findings of Holub *et al.*, in no case did the consumption fall or remain at the same level with exposure to the lower temperature. The results for three groups of pigs are given in Table 1. The average figures for oxygen used were 23·3, 36·4 and 24·6 ml./kgm.min. for the three succeeding periods at average temperatures of 23·4°, 3·9° and 22·9° C., respectively, and the differences between consumptions at the two temperatures are highly significant for all three age-groups.

The rectal temperature changes are given in Table 2. The fall was most marked in the youngest group at 3° C., but even here considerable recovery took place during the third measurement period, at 23° C. At 5–6 days of age, rectal temperature did not change during the period at 3° C.

Table 2. INITIAL RECTAL TEMPERATURES OF NEW-BORN PIGS AND CHANGES OCCURRING DURING EACH PERIOD OF MEASUREMENT. SIX PIGS IN EACH AGE GROUP

Age	Initial rectal temperature (°C.) Mean ± S.E.	Rectal temperature changes during 1st period (°C.) Mean ± S.E.	2nd period (°C.) Mean ± S.E.	3rd period (°C.) Mean ± S.E.
Under 1 day	38·6 ± 0·1	−0·4 ± 0·1	−1·7 ± 0·3	0·9 ± 0·2
2–4 days	39·1 ± 0·2	−0·3 ± 0·02	−0·6 ± 0·2	0·2 ± 0·2
5–6 days	39·5 ± 0·3	−0·4 ± 0·1	0 ± 0·1	−0·2 ± 0·1

Thus these results show a vigorous response from the new-born pig to lowering of the environmental temperature, in contrast with the absence of response found by Holub *et al.* under similar conditions, and using the same breed of pig. Moreover, this response occurred with pigs, down to 1 hr. of age, which had not been suckled previously by the sow, whereas the youngest animals used by Holub *et al.* were 3 days old. The type of response in respect of oxygen consumption reported here for new-born pigs was not found by Holub *et al.* in pigs younger than 9–10 days of age, and the same is approximately true for rectal temperature changes; the changes in rectal temperature for pigs up to 4 days old (Table 1) correspond generally with those found by Holub *et al.* in pigs aged 10–20 days.

The possibility arises, therefore, that these contrasting results are due to pigs differing constitutionally in their response to lowered environmental temperature. However, before such an outstanding variation among pigs could be accepted, it would be necessary to establish equality of experimental conditions between the two series of experiments.

It is concluded that under the conditions described here the new-born pig responds to a drop in environmental temperature from 23° to 3° C. by a rise in the production of heat of the order of 50 per cent.

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Ringed Appearance of Lipid Spheres under the Phase-Contrast Microscope

Recently, Chou and Bradbury[1] have pointed out some optical artefacts produced in the appearance of fat droplets under the phase-contrast microscope. They say that homogeneous fat droplets may have a "crescentic" appearance if examined in a non-axial light source or an eccentric condenser. They also point out that in a fully centred system the appearance of such a fat globule is a "perfectly symmetrical sphere with a dark rim or apparent 'cortex' surrounding the bright region within".

A great variety of living cells have been examined in this laboratory[2] under phase-contrast and interference microscopes and it has been often observed that a non-axial phase-contrast system gives the typical "crescentic" appearance to the lipid spheres that occur so commonly in the animal oocytes, gland cells, and neurones. Such an artefact, however, can easily be detected since it invariably causes a great loss in overall contrast, as is quite evident from the photomicrograph *B* in Fig. 1 of Chou and Bradbury[1].

The ringed appearance of fat or lipid droplets in a perfectly adjusted phase-contrast system has, however, led many cytologists to misinterpret the structure of these homogeneous lipid spheres as duplex.

Similarly, students of oogenesis have very commonly described the so-called Golgi bodies (lipid spheres) as duplex vesicles with a dark cortex and a clear medulla, after using such apparently harmless techniques as fresh coverslip preparations treated with osmium tetroxide solution for short periods[2]. These workers were further misled by the exactly similar appearance of these Golgi bodies under the phase-contrast microscope, in the living material, especially in the animal oocytes. Some extensive work in this laboratory on the histochemistry of oocytes has conclusively shown that these Golgi bodies are nothing but homogeneous lipid spheres colouring uniformly with sudan black *B* in ordinary circumstances. The duplex appearance of the lipid spheres of some oocytes in sudan black *B* has no correlation with their duplex appearance either in osmium tetroxide solution or in the living cells examined under the phase-contrast microscope, because, in such cases, the duplex appearance in sudan black *B* is due to the presence of either solid or masked lipids[3]. This appearance can easily be changed by using special techniques. That the duplex appearances of the homogeneous lipid bodies under the phase-contrast microscope are optical artefacts becomes amply clear from the observations on earthworm oocytes and human oral epithelium, described below.

The oocytes of *Pheretima posthuma* have numerous lipid spheres in the cytoplasm besides the mitochondria and some clear vacuoles. There is no yolk. The lipid spheres colour homogeneously, without any clear medulla whatsoever, in sudan black *B* used on gelatin sections of material fixed with formaldehyde-calcium (Fig. 1*a*). In the living oocytes examined under the phase-contrast microscope the larger spheres appear as clear and sharp rings (Fig. 1*b*).

The loose human oral epithelial cells have a number of homogeneous sudanophil lipid spheres of various sizes. The larger ones always have a ringed appearance under the phase-contrast microscope (Fig. 1*c*).

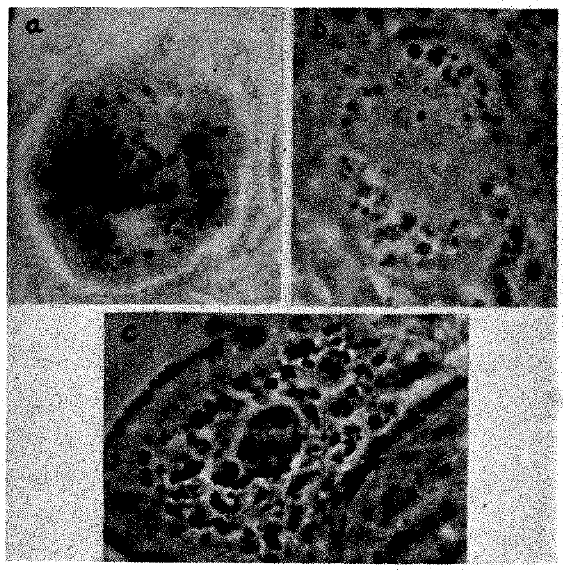

Fig. 1

Some similar observations were also made by Roque[4] on the neurones of the gastropod, *Helix*. These observations clearly show that the duplex or ringed appearance of the lipid spheres under the phase-contrast microscope is an optical artefact.

It may be mentioned that the duplex ringed or crescentic appearance given by the Golgi bodies in the male germ cells (for example, in pulmonate gastropods[4,5]) and certain gland cells (for example, liver cells of *Anadenus*[6,7]) under the phase-contrast microscope are not to be considered artefacts as they have a non-lipid core.

Great care should therefore be taken in interpreting the appearance under the phase-contrast microscope of cell inclusions in general and lipid spheres in particular; these may always be checked carefully using some vigorous lipid colourant like sudan black *B*, as was also pointed out by Baker[8].

Carl Zeiss (West Germany) stand *W* and Leitz 'Dialux' microscopes with phase-contrast systems were used in this work. Living cells were mounted in Baker's[9] physiological solution.

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Counting of Sulphate-reducing Bacteria in Mixed Bacterial Populations

In the dilution method of counting *Desulphovibrio* in soil or water, a selective medium containing lactate and inorganic salts is commonly employed. The growth of a sulphate reducer is recognized by the appearance of the black colour of ferrous sulphide. Since the organisms are anaerobes and the medium is simple in composition the addition of a reducing agent is essential. Grossman and Postgate[1] selected cysteine as the most suitable of the reducing substances they examined. Cysteine possesses the disadvantage that it may be attacked with the liberation of sulphide by certain bacteria which do not reduce sulphate. Hence it is necessary to apply some test to confirm the presence of *Desulphovibrio* in cultures which become black. A further disadvantage in the method proposed by Grossman and Postgate is that the cultures are incubated in an anaerobic atmosphere.

Much interest has been taken in the corrosive action on iron for which *Desulphovibrio* is notorious. In contrast, little attention has been given, except by Starkey and Wight[2], to the favourable influence of elemental iron on the growth of the organism. It has been recognized for a long time that metallic iron will lower the oxidation-reduction potential of media to a level suitable for *Clostridia*, and that these anaerobes will multiply readily in tubes of liquid media incubated in air if a strip or rod of iron is included in the medium. This suggested that for the purpose of dilution counts of *Desulphovibrio*, iron, which would not affect the selectivity of a synthetic medium, might be used to provide the necessary reducing conditions. Iron was therefore tested in a medium used by Starkey[3]: sodium lactate, 3·5 gm.; NH_4Cl, 1 gm., K_2HPO_4, 0·5 gm.; $MgSO_4.7H_2O$, 2 gm.; Na_2SO_4, 0·5 gm.; $CaCl_2$, 0·1 gm.; Mohr's salt, trace; and tap water to 1,000 ml.; *p*H 7. The medium was sterilized in quantities of 5–7 ml. in 5/8-in. tubes. Iron was added as a nail 3–5 cm. long and 0·3–0·4 cm. thick, either before or after the tubes of medium were sterilized. Other supplements were sterilized in the medium. All media were used soon after preparation. In examining soil or water a series of decimal dilutions was prepared in sterile physiological saline and 1 ml. of each dilution was transferred to each of five tubes of each medium. Incubation was at 30° C. Anaerobic conditions were provided by pyrogallol and sodium carbonate.

Some typical results are shown in Table 1. Iron appears to be at the least as effective as cysteine in promoting the growth of sulphate reducers, and it possesses an advantage over cysteine in not giving rise to false positive results. A finding which greatly simplifies the technique of counting the organisms is that the iron medium may be incubated in air. More than a hundred trials of this medium have been made comparing aerobic with anaerobic incubation; no definite difference could be detected in the results. If the medium containing cysteine were similarly incubated in air the problem of its selectivity for sulphate reducers would arise. A conclusion which may be drawn, incidentally, from this work is that where iron occurs in soil or water into which oxygen penetrates, *Desulphovibrio* could easily find conditions which permitted its growth and its corrosive action on the iron.

Table 1. Influence of Metallic Iron on Growth of Sulphate-reducing Bacteria

	Medium	Anaerobic incubation	Number of positive tubes at a dilution of*					
			10^{-1}	10^{-2}	10^{-3}	10^{-4}	10^{-5}	10^{-6}
Soil	Starkey's	+	5	0	0	0	0	0
	Starkey's + sodium thioglycollate, 0·1 per cent	+	0	0	0	0	0	0
	Starkey's + sodium thioglycollate, 0·1 per cent + 'Difco' yeast extract, 0·25 per cent	+	5	0	0	0	0	0
	Starkey's + 'Difco' yeast extract, 0·25 per cent + nail	+	5	5	5	4	0	0
	Starkey's + nail	+	5	5	5	4	0	0
Water	Starkey's + nail	+	5	5	5	4	0	0
	Starkey's + nail	–	5	5	5	4	1	0
Water	Starkey's + nail	+	5	5	5	5	2	0
	Starkey's + nail	–	5	5	5	5	1	1
Soil	Starkey's + nail	–	5	5	4	2	0	0
	Starkey's + cysteine, 0·1 per cent	+	5	5	5	1	0	0
Soil	Starkey's + nail	–	5	5	3	1	0	0
	Starkey's + cysteine, 0·1 per cent	+	5	5	4(1)	1(4)	0(1)	0
Soil	Starkey's + nail	–	5	5	2	1	0	0
	Starkey's + cysteine, 0·1 per cent	+	5	5	2(3)	0(5)	0(3)	0

* Figures in parenthesis indicate false positive results.

We wish to thank Dr. T. Gibson, of the Edinburgh and East of Scotland College of Agriculture, for helping in the presentation of this communication.

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Eichornia crassipes in the Nile of the Sudan

During an expedition made by the Hydrobiological Research Unit of the University of Khartoum in March and April 1958, *Eichornia crassipes* was encountered in the White Nile and Bahr el Gebel along about 1,000 km. of the river system. Observations were made in part from the Unit's launch (from Khartoum to the Sobat Mouth) and in the southern reaches (from the Sobat Mouth to Juba) from a Sudan Railways steamer. The latter travelled

Table 1. DISTANCES IN KM. UPSTREAM OF KHARTOUM OF PLACES MENTIONED IN THE TEXT. (Compiled from Sudan Almanac, 1956)

White Nile	Khartoum	—
,,	Gebel Aulia Dam	47
,,	Kosti	319
,,	Gebelein	394
,,	Geigar	460
,,	Malakal	819
,,	Sobat Mouth	844
,,	Zeraf Mouth	888
	Lake No (mouth of Bahr el Ghazal)	964
Bahr el Gebel	Zeraf Cuts	1,252
,,	Shambe	1,372
,,	Juba	1,754

night and day so the southernmost limit of the plant could not be recorded precisely.

Former members of the Hydrobiological Research Unit, Catholic missionaries in the southern Sudan and many Sudanese whose lives are centred on the river agree that they had not seen the plant prior to the winter of 1957–58. Its spread has therefore been of an explosive nature. Recent detailed examination of the photographs which I took in December 1956 on an expedition to the White Nile and Bahr el Ghazal suggests that it may have been present in one or two stations in the Bahr el Ghazal, but this would require confirmation by further field work.

Eichornia occurs either as free-floating mats, as marginally fixed yet floating mats, or as a terrestrial plant of the damp river margins, where it frequently becomes stranded. It reproduces vegetatively by tillers which persist and hold large numbers of individuals together in mats of up to 50 m.^{2}, but usually much less. Its height varies from about 8 cm. to about 40 cm. It flowers abundantly, but the part played by such reproduction was not assessed.

At Kosti (see Table 1) *Eichornia* formed a conspicuous part of the floating marginal vegetation and as drift it was found downstream of the town in small quantities. It occurred from here southwards to the approximate vicinity of Shambe, but its status both as a marginal type and as drifting islands varied considerably, and this variation is analysed briefly below. It was particularly abundant in the Kosti–Gebelein and Malakal–Zeraf Mouth reaches. No drift was seen in, or issuing from, the River Sobat or the Bahr el Ghazal, but as the mouth of the Bahr ez Zeraf was passed in the night no observations can be recorded for that river. The Zeraf Cuts (the artificial capture by the Bahr ez Zeraf of part of the waters of the Bahr el Gebel) are downstream of the most southerly occurrence of *Eichornia* so it is extremely likely that the Bahr ez Zeraf also has the plant.

Eichornia was more common marginally where the river margin was dominated by various Gramineae, especially *Vossia cuspidata*, which advance into the river irregularly, thus creating bays, at least in the season when the river current is slack. Such situations presumably reduce the drag of the river current upon the comparatively loosely attached *Eichornia* mat and were formerly occupied by ecologically similar types, for example, *Pistia stratiotes*, *Azolla* spp. and *Lemna* spp., which in the reaches where *Eichornia* is present have been more or less eliminated. *Eichornia* appears to be the most successful in the competition for this ecological niche.

Its occurrence in relation to swamp types in part explains its distribution in the river system. (1) Upstream of Shambe the river current is strong and papyrus is usually the marginal type. As this species maintains a fairly simple straight front on to the river there are few niches suitable for *Eichornia*. (2) The Kosti–Gebelein and Malakal–Zeraf Mouth reaches are both where the riverain swamp is well developed in a form allowing the marginal attachment and breeding of the plant. (3) The most downstream occurrence (near Kosti) roughly parallels that of papyrus (which is also dispersed in part at least as drift), and downstream of this station the swamps are of a different character, largely owing to the effect of the Gebel Aulia Dam on the amplitude of the river level.

As for all other free-floating river vegetation the distribution pattern of *Eichornia* drift in the river can be related to at least two factors, namely, a source of supply, and a means of bringing plants into the river[1]. Undoubtedly drifting *Eichornia* was more common in, and immediately downstream of, regions where its marginal development was good, but an example will show that its distribution cannot be simply related to a source of supply. At Geigar one evening *Eichornia* drift was abundant; the following morning it was scarce. It is suggested that local storms, so common in the tropics, are an important means of bringing drift into the river and thus explaining its temporal distribution pattern. During one such storm the strong winds and the wave action so induced on the river were seen to break the attachments of marginal *Eichornia* and release it as drift.

The Nile is of vital importance to the Sudan as a line of communication. Already *Eichornia* drift is constituting a minor nuisance to the Sudan Railways steamers by becoming wedged between the driving unit of the steamer and its barges (which are lashed to either side and fore of the driving unit) thus interfering with water intake for engine cooling. Such a nuisance has arisen in the few months that *Eichornia* has been in the Nile. The Congo and many other tropical rivers are witness to the probable result of its continued explosive development.

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Chelation or Complex-formation by Indoleacetic Acid *in vitro*

AFTER a long series of attempts to demonstrate chelation or complex-formation between 3-indoleacetic acid and metal ions *in vitro*, which were unsuccessful presumably because of the very low concentrations of indoleacetic acid inevitable in the aqueous solutions used, we repeated the experiments of Cohen *et al.*[1], using, as they did, cupric nitrate and indoleacetic acid in 50 per cent ethanol. Essentially similar results were obtained, except that our value for log K by the Bjerrum method was 3·0 as compared with theirs of 5·4; we were also not entirely satisfied that a discontinuity in our curve for absorption at 360 mμ versus composition occurred at a ratio of 1 copper : 2 indoleacetic acid and there was no indication of a break at 1 copper : 1 indoleacetic acid (*cf.* their Fig. 2).

We also carried out similar experiments with ferric ions, which these authors found to be strongly chelated

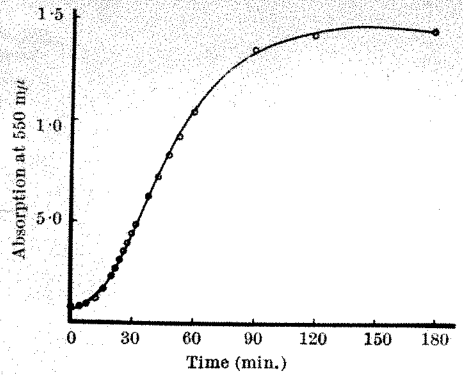

Fig. 1

by 3-indoleacetic acid. The Bjerrum method gave us a value of $\log K$ of 6·0. Measurements of absorption spectra for a solution of 4×10^{-3} *M* ferric chloride and 10^{-1} *M* indoleacetic acid in 50 per cent ethanol showed a strong development of colour, especially between 450 and 600 mμ. It was observed, however, that the intensity of the colour in the mixture increased with time, suggesting either that chelation was very slow or that a progressive break-down of indoleacetic acid to some coloured compound was occurring. The development of colour at 550 mμ in a mixture containing 4×10^{-3} *M* ferric chloride and 2×10^{-3} *M* indoleacetic acid (*p*H 2·6) was measured against time and found to reach a maximum after about 2 hr. (Fig. 1).

To investigate the possibility of break-down of indoleacetic acid, ferric chloride (4×10^{-3} *M*) and indoleacetic acid (2×10^{-3} *M*) were allowed to react in 50 per cent ethanol in Warburg flasks, with shaking, in darkness and at a temperature of 20° C. The output of carbon dioxide and uptake of oxygen with time are shown in Fig. 2. From a similar mixture in a Warburg flask under similar conditions, samples were removed at intervals and tested for indoleacetic acid content by the Salkowski method (Tang and Bonner[2]); the change with time is shown in Fig. 2. It is clear that the presence of ferric ions induced decarboxylation and consequent destruction of almost all the indoleacetic acid with the uptake of an equal volume of oxygen, giving a coloured substance.

Manometric measurements and Salkowski tests on mixtures containing 2×10^{-3} *M* indoleacetic acid and 4×10^{-3} *M* cupric nitrate under the same conditions gave no measurable gas exchange, but 10 per cent break-down of indoleacetic acid occurred over 4½ hr.

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Effect of Fumigation and Moisture Content on the Seedling Growth of Cowpea (*Vigna unguiculata*)

It has been shown[1] that the fumigation of maize grain with a 1 : 1 mixture of ethylene dichloride and carbon tetrachloride adversely affects the growth of seedlings raised from the grain. Similar results have now been obtained from a study of the early growth of cowpeas raised from fumigated seed.

A supply of cowpea was obtained which had a moisture content of 12 per cent, and half was dried to a moisture content of 10 per cent by spreading out in a room with a low atmospheric humidity. Two 2-lb. jars were filled with seed at each moisture content, and one of each of these was fumigated with a 1 : 1 mixture of carbon tetrachloride and ethylene dichloride at a concentration of 20 cm.^{3} of total storage volume. All the jars were sealed and after two months they were opened and 30 seeds from each of the two treatments and two controls were taken and planted 10 per pot in 8-in. pots filled with garden soil. Eleven days after sowing, the plants which had grown were removed and their fresh weights determined (Table 1).

From a comparison of the results for the two control series it is evident that drying the seed to the lower moisture content had a retarding effect on early growth. Most plants grown from seed of 12 per cent moisture content were more than 2·0 gm. in weight, whereas most of those from seeds with a moisture content of 10 per cent weighed 1·1–1·4 gm. at the end of the experiment.

The effect of fumigation was particularly noticeable with seedlings arising from seeds with the higher moisture content; a quarter of the seedlings in this group weighed less than 0·2 gm. Plants grown from seeds with the lower

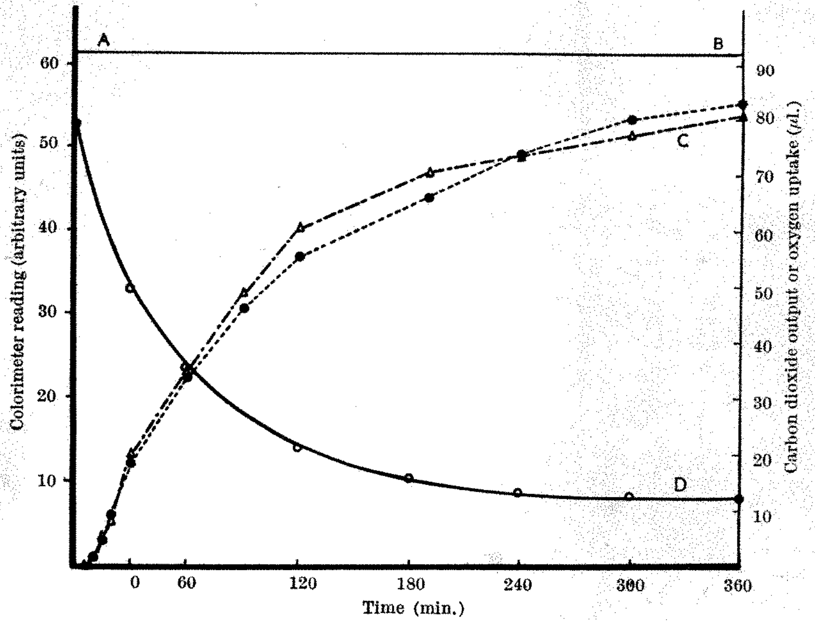
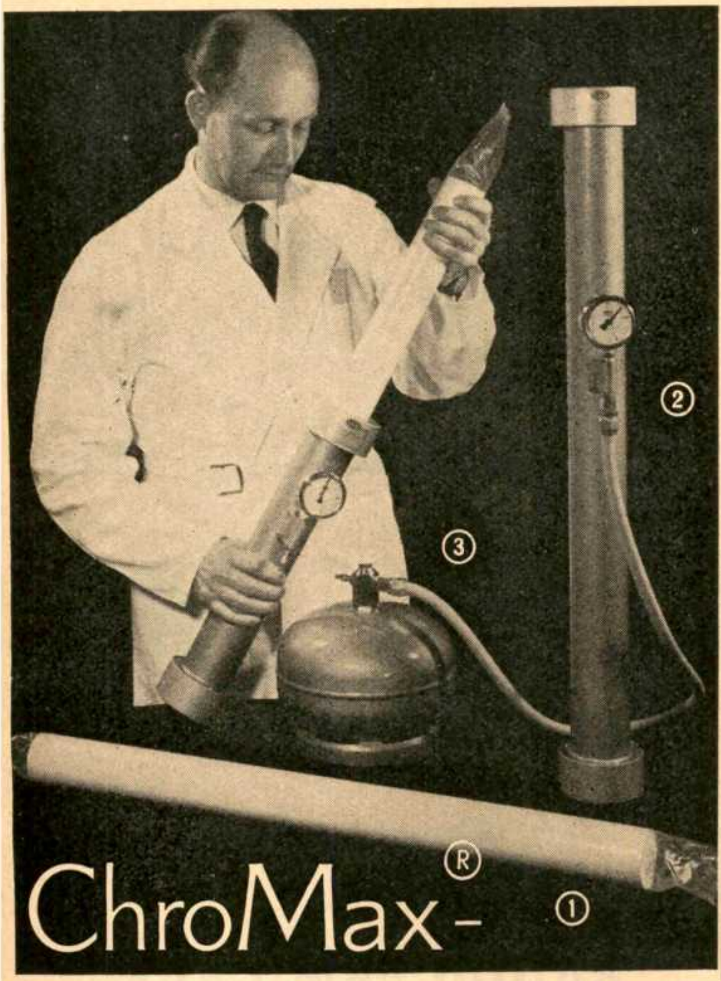


Fig. 2. *AB*, Theoretical output of carbon dioxide (μl.) for complete breakdown of 3-indoleacetic acid; *C*, 89 per cent breakdown of 3-indoleacetic acid, output of carbon dioxide (△) and oxygen uptake (●); *D*, colorimeter reading for 84 per cent breakdown of 3-indoleacetic acid



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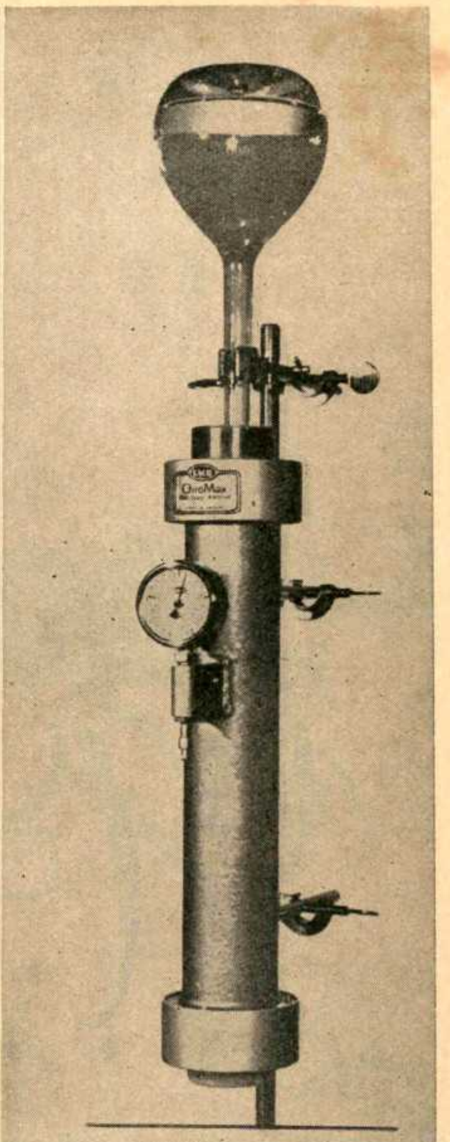

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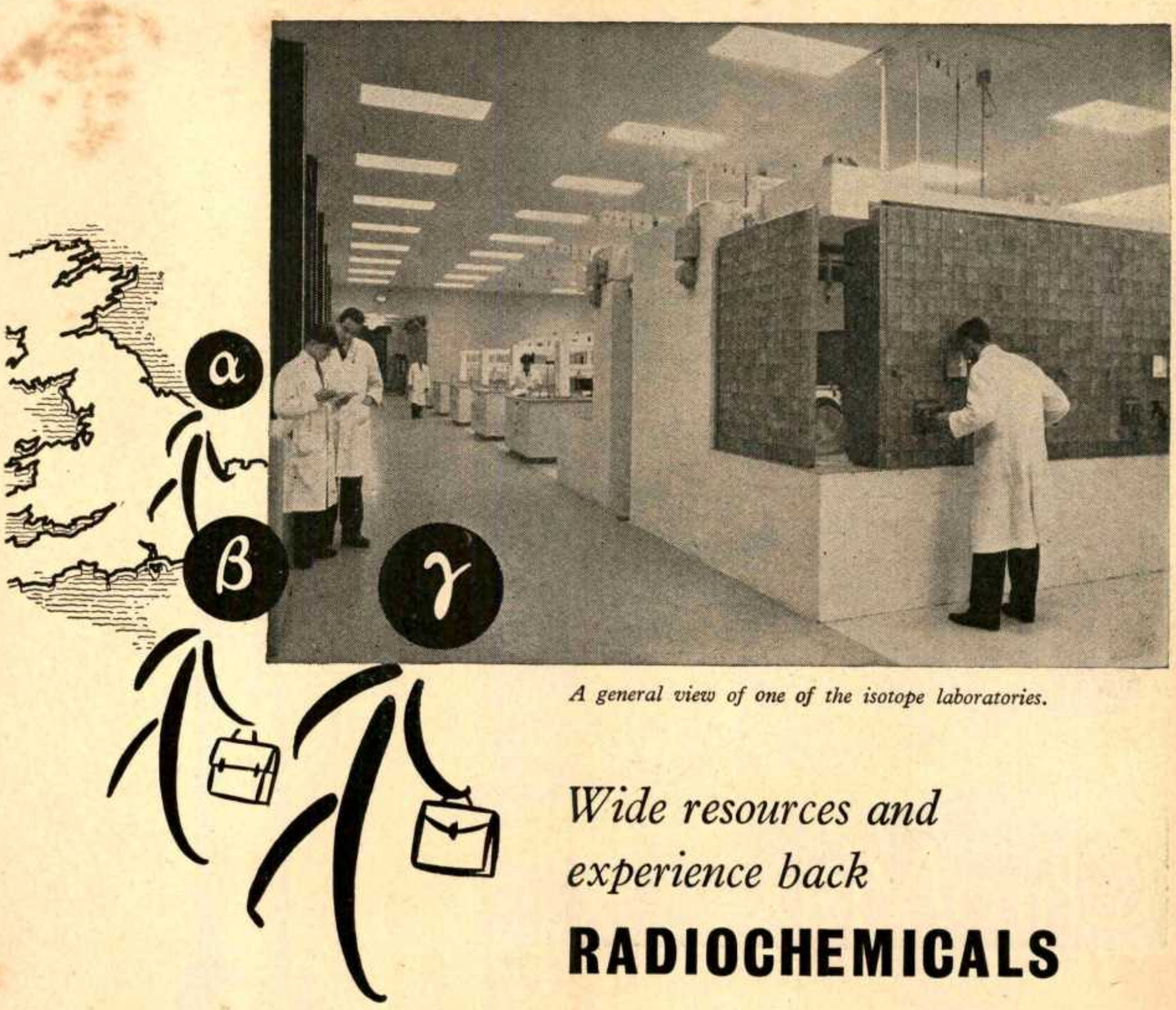

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Table 1. FRESH WEIGHTS OF SEEDLINGS GROWN FROM FUMIGATED AND UNFUMIGATED SEED OF DIFFERENT MOISTURE CONTENTS

Fresh weight (gm.)	Number of plants			
	10 per cent moisture		12 per cent moisture	
	Control	Treated	Control	Treated
0·0–0·2	—	1	1	7
0·3–0·5	1	5	1	1
0·6–0·8	1	4	2	0
0·9–1·1	6	5	1	1
1·2–1·4	10	6	7	2
1·5–1·7	5	1	2	3
1·8–2·0	4	2	4	3
> 2·1	3	4	12	10
Total	30	28	30	27

moisture content did not appear to suffer so drastically from fumigation though their general growth was retarded.

It seems likely from work still in progress that the retardation of growth in seedlings from seeds with the lower moisture content is only temporary and will not affect the ultimate yield. However, the severe retardation observed for about a quarter of the plants grown from the moister seeds that had been fumigated is likely to be permanent, the seedlings being deformed and only slowly, if ever, reaching maturity.

The above results stress the need for measuring growth and yield as well as germination when considering the effect of fumigants on stored seed to be used for planting.

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An Age Effect on Seta Elongation in *Pellia epiphylla*

IN a recent communication, Asprey *et al.*[1] report that spraying with indolylacetic acid and gibberellin effects elongation of the setæ of *Pellia epiphylla* in January, whereas under normal conditions this is delayed until late February or early March. We have obtained results which suggest that during the winter months a gradual change occurs, bringing setæ into a condition when they are capable of rapid elongation once the temperature is raised. In view of the results of Asprey *et al.*, this internal change may well be correlated with synthesis of growth hormones.

Table 1. EFFECTS OF AGE, RISE IN TEMPERATURE AND EXTRA LIGHT ON SETA ELONGATION

Time (weeks) from collecting material until 50 per cent of the setae started to elongate

Treatment	Date collected					
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
15° C., normal light	20	14·5	8	5·5	2·5	0·5
15° C., normal light*	21	14	9	—	—	—
15° C., normal light + 10 f.c. tungsten light for 16 hr. each day	—	10	6·5	4·5	2	0·5
15° C., normal light + 10 f.c. tungsten light for 16 hr. each day*	15	9·5	7	—	—	—

* Kept 2 weeks at 1° C. immediately after collection.

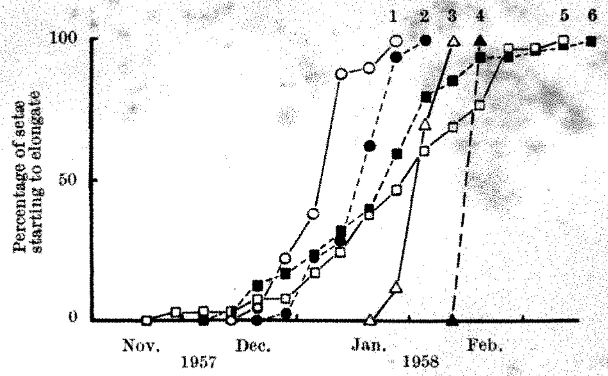

Fig. 1. Effect of age on the ability of setæ to elongate when transferred to 15° C. Material in the field showed no seta elongation until March 1958. Dates transferred: 1, November; 2, December; 3, January; 4, February; 5, September; 6, October

Fresh material of *Pellia epiphylla* was collected from a site near Southampton at intervals from mid-September 1957 to February 1958 and kept in a warm greenhouse (mean temperature 15° C., minimum 10° C.). The number of setæ elongating was counted at weekly intervals and the capsule contents also examined. Fig. 1 shows that rise in temperature promotes seta elongation in every case (material left in the field did not start to elongate until March 1958), but the most marked effect is that of age of the sporophyte. This is shown more clearly in Table 1, which records the lag period before 50 per cent of the setæ start to elongate. Two weeks cold treatment (1° C.) given immediately after material had been collected did not affect the results, but provision of extra light shortened the lag period slightly. It is tentatively suggested that during the winter there is a slow synthesis of growth hormones (or removal of a growth inhibitor), which is stimulated to some extent by a rise in temperature and extra light. The fact that the maximum length reached by setæ was considerably less in samples collected early in the season would also support this idea. It would be of particular interest to know if indolylacetic acid and gibberellin are effective in promoting seta elongation in material collected in the autumn.

Subsidiary observations were made on spore development, since it has been suggested that maturation of the spores is the stimulus for seta elongation. Under normal conditions the tetrads divide into spores at the end of November, but material collected in September and October before this change had occurred and kept at a warm temperature, had not formed spores by March 1958, when observations were discontinued. Despite immaturity of the spores seta elongation occurred (Table 1), and it is therefore highly improbable that there is a direct relationship between spore maturation and seta elongation. A similar conclusion was reached by Asprey *et al.* from their experiments. A further observation supporting this was that two weeks cold treatment was effective in stimulating tetrad division in material collected in October, but seta elongation was unaffected.

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Nematoses of Pyrethrum in East Africa

Dalmatian pyrethrum (*Chrysanthemum cinerariaefolium*) (Trev.) Vis. is widely attacked in Kenya and Tanganyika by species of the nematode genus *Meloidogyne* Goeldi (root-knot nematodes), in particular *Meloidogyne hapla* Chitwood, 1949, which is a new host record.

Interveinal chlorosis and necrosis of the leaf lamina are invariably associated with heavy leaf populations of *Aphelenchoides ritzema-bosi* (Schwartz) Steiner.

While considerable economic importance must be attached to root galling of commercial pyrethrum by *Meloidogyne* spp., a recently discovered root-rot disease associated with high root populations of an apparently new species of the genus *Pratylenchus* Filipjev may prove of equal importance in pyrethrum farms at altitudes between 7,000 and 9,000 ft. This disease, although suspected in several areas of Kenya, was first found on a two-year-old planting at 8,500 ft. near Limuru, Kenya. Of 72 random samples of roots with surrounding soil, collected in groups of 24 at bi-monthly intervals from three adjacent terraces of very stunted plants, 57 were affected by a root-rot disease, with which *Pratylenchus* n.sp. was invariably associated. Heavy attacks of *M. hapla* were also present but not correlated with the symptoms of root-rot.

The first sign of this root-rot is the appearance of small patches of a brownish discoloration on the root epithelium. These lesions increase in area, darken and penetrate to the stele, girdling and eventually producing an almost completely blackened root. Eggs, larvæ and adults are found in affected tissue, specimens being recoverable even from the smallest lesions. Other nematodes and fungi are found in the later stages of the disease but not apparently in the early lesions.

Although *Pratylenchus* spp. have been reported in species of *Chrysanthemum* (Tourn.) L.[1-4] invasion and reproduction in the roots of *C. cinerariaefolium* by *Pratylenchus* n.sp. constitutes a new host record. A detailed description of the parasite will be published elsewhere.

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Heavy Infestation by the Parasitic Copepod *Lernaeenicus* of Sprats in the River Crouch

Whitebait sprats in the estuary of the River Crouch collected in May 1957 were found to be heavily infested with copepod parasites. The fishes were collected by using a 12-ft. beam trawl with shrimp netting, several hauls being made between Burnham-on-Crouch and Holiwell Point, just inside the mouth of the River Crouch in Essex. Of the 140 sprats (*Culpea sprattus*) captured, 43 (31 per cent) were afterwards found to be parasitized by the copepod *Lernaeenicus*. The two British species of this genus, *L. sprattae* and *L. encrasicola*, were both present. It is a general rule that *L. sprattae* is fixed in the eye of the fish while *L. encrasicola* has its head buried in the tissues of the body, usually in the back, and the present sample was no exception to this rule. The sprats may be divided into the following categories :

97 sprats with no copepod parasites
32 sprats with one *L. sprattae* in one eye
2 sprats with two *L. sprattae* in one eye
7 sprats with one *L. encrasicola* in the back
1 sprat with two *L. encrasicola* in the back
1 sprat with one *L. sprattae* in an eye and one *L. encrasicola* in the back

L. sprattae is most easily distinguished from *L. encrasicola* by the moniliform appearance of the neck, as can be seen in Fig. 1. There is no doubt that the present infestation of more than 30 per cent of the fish is a severe one, but there are very few records in the literature which give a definite indication of the number of sprats parasitized in a sample. Leigh-Sharpe[1] gives 3 per cent infestation for two samples taken at Hole's Hole, near Plymouth, independently by himself and Dr. R. Gurney in 1934, and he quotes T. Scott and A. Scott's[2] earlier figure of 2·3 per cent at Plymouth in 1910. Among Gurney's manuscript papers now in the British Museum there is a note directing attention to the remarkable fact that his specimens of *Lernaeenicus* from Hole's Hole, from more than 1,000 fishes, collected on April 10, 1934, were young, not one of them being fully grown or bearing eggs, while Leigh-Sharpe's specimens from 970 sprats, collected from the same place in the spring of the same year, presumably a little later though the actual date is not known, were mature and bearing eggs. A rapid growth of the parasite is indicated, with presumably an adverse effect on the host.

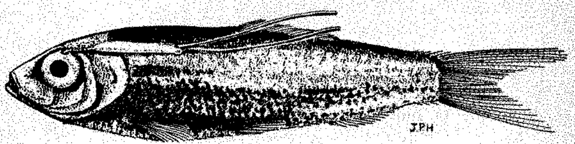

Fig. 1. A sprat about 5 cm. long with a parasite (*Lernaeenicus sprattae*) embedded in the eye. Note the hole in the eye, the moniliform shape of the neck and the two long strings of eggs which stream out from the hinder end of the cylindrical body of the parasite

In the rather overcrowded conditions of fish farms in hot countries, infestations of the fishes by the similar copepod *Lernaea* sometimes occur which are more severe than any known under natural conditions ; Nakai[3] describes eels and loaches with the buccal cavity so crowded with parasites that food could not be swallowed. Very little, however, is known about the effect on fishes, under natural conditions, of copepod parasites of this type which live with the head buried in the tissues of the host, presumably feeding on blood and other fluid tissues. It was thought that with such a large sample of fish, both with and without parasites, it would be easy to detect signs of unhealthiness in the parasitized fishes, but this was not so, even statistically. The shape-index (S) was calculated for each fish using the formula $S = K \frac{\sqrt[3]{w}}{l}$ where w is the weight in gm., l the standard length in cm., and K is a constant. For fishes of the same length, the greater the weight the greater the shape-index. Each of 138 fishes was measured individually to the nearest mm. and weighed to the nearest 10 mgm., two of the original sample were discarded owing to damage, one of them parasitized. The value of K used (5·14) is such that a normal fish has the shape-index of 1·0, in other words, of the 138 fishes measured, 69 had an index of less than 1·0 and 69 greater than 1·0. The shape-index of each fish is plotted against its length in Fig. 2. On the left side of the figure are the fishes without parasites and on the right, for comparison, are the smaller number with parasites. The pattern of distribution shown in this figure is substantially the same for both groups of fishes. Of the 42 parasitized fishes measured, 25 had a shape index greater than, and 17 less than, unity; and of the 96 healthy fishes 44 had an index greater than, and 52 less than, unity. This would indicate a beneficial effect of the parasite on the weight of the fish, but the difference is slight and probably not statistically significant.

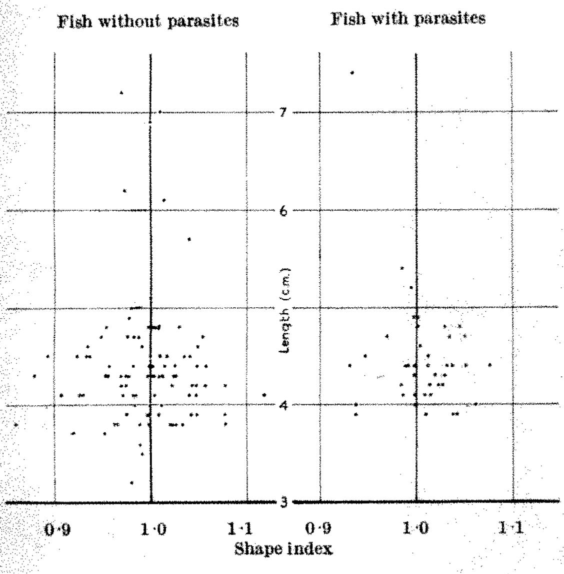

Fig. 2. Shape index and length distributions of parasitized and normal fishes

The lengths of the fishes shown in Fig. 2, varying from 3·2 to 7·4 cm. in standard length, fall within the size range given by Robertson[4] for samples of whitebait sprats from the Thames Estuary, which he considered to be mainly composed of 0-group fishes. The considerable size-range is probably a reflexion of the prolonged spawning season of sprat in the North Sea—March to August (maximum in June); and the few large fishes, one of which was parasitized, were probably spawned early in the season and were thus 1-group or close to it when caught. This conclusion, which is in conformity with Robertson's findings, was supported by an examination of the few scales present on two of the large sprats which appeared to be those of 1-group fishes.

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Movement of Salmon on the River Erne

A graphic record of salmon (*Salmo salar*) ascending the fish pass at Cathaleen's Fall Hydro-Electric Generating Station has been kept for four fishing seasons. This station is one of two erected by the Electricity Supply Board, Ireland, on the River Erne. It is located at the toe of a dam across the river and has an installed capacity of 45,000 kW. and a gross head of approximately 100 ft.

The fish ladder extends from the power station tailrace over the dam into the head waters. The tailrace is tidal. The ladder is of the White submerged-orifice type similar to those developed and used by the North of Scotland Hydro-Electric Board at its Pitlochry and Clunie power stations. It has 73 pools with a difference in water-level of 1½ ft. between successive pools. Some of the bottom pools are, however, submerged except at low tide or when the turbines in the power station are not operating; some of the top pools are by-passed at low reservoir levels. Orientation of the pass is approximately east–west.

The counter is of the nylon-screen type developed by the Board and has as an accessory a recording voltmeter which shows on a chart the time of the passage of each fish through the counter.

A preliminary analysis of the results so far available indicates the following movements of salmon: (*a*) an almost complete cessation of activity during hours of darkness; (*b*) greatest activity between noon and dusk; (*c*) the number of fish travelling singly is small in comparison with the total count.

P. A. Jackson

Cathaleen's Fall Generating Station,
Ballyshannon,
Co. Donegal.
June 27.

Pigmy Sperm Whale (*Kogia breviceps*) in Borneo

In recent years the Sarawak Museum has developed a system by which people along the west coast of Borneo report (if they have time) the occurrence of any beached cetacean. Partly by this means, and with the help of Malays and Dayaks, we have extended the local list from five to fourteen known forms in the past five years, advised and criticized by Dr. F. C. Fraser, of the British Museum (Natural History).

In 1956, and again in 1957, complete examples of the comparatively rare Bryde's whale (*Balaenoptera brydei*) were obtained in this way, and on February 19, 1958, we were able to recover from Buntal in south-west Sarawak, a perfect specimen of the very little-known pigmy sperm whale (*Kogia breviceps*). This miniature 10-ft. version of the sperm whale—the greatest of all the toothed cetaceans—has not previously been recorded from this part of the world. Of added interest was the presence of a well-developed embryo. A beautiful baby, of a battleship-grey, it is 14½ in. long. Two of seven previously recorded embryos are from European waters.

Photographs and measurements have been sent to the British Museum (Natural History) for confirmation of identification.

Tom Harrisson
George Jamuh

Sarawak Museum,
Borneo.

FORTHCOMING EVENTS

Wednesday, August 27—Wednesday, September 3

British Association for the Advancement of Science (at Glasgow).—Annual Meeting.

Wednesday, August 27

At 7.15 p.m.—Sir Alexander Fleck, F.R.S.: "Science and Business: a Balanced Partnership" (Presidential Address).

Thursday, August 28

At 10 a.m.—Prof. H. J. Emeléus, F.R.S.: "The Chemistry of the Transuranic Elements" (Presidential Address, Section B).

At 10 a.m.—Dr. A. S. Parkes, F.R.S.: "Some Biological Effects of Low Temperatures" (Presidential Address, Section D).

At 10 a.m.—Prof. R. S. Adamson: "The Cape as an Ancient African Flora" (Presidential Address, Section K).

At 10 a.m.—Dr. D. P. Cuthbertson: "Digestion in the Ruminant" (Presidential Address, Section M).

At 11.15 a.m.—Prof. H. M. Steven: "The Native Pinewoods of Scotland and their Significance for Current Forestry Practice" (Chairman's Address, Section K*).

At 11.30 a.m.—Prof. R. W. Bickford: "A Review of Some Problems of Colour Vision and Colour Blindness" (Presidential Address, Section J).

At 2.15 p.m.—The Rt. Hon. Lord Boyd Orr, F.R.S.: "The Cultural Value of Local Societies" (Presidential Address, Section X).

Friday, August 29

At 10 a.m.—Prof. E. Estyn Evans: "The Atlantic Ends of Europe" (Presidential Address, Section E).

At 10 a.m.—Prof. A. J. Brown: "Inflation and the British Economy" (Presidential Address, Section F).

At 10 a.m.—Prof. O. A. Saunders, F.R.S.: "Heat and the Engineer" (Presidential Address, Section G).

At 11.30 a.m.—Sir Willis Jackson, F.R.S.: "The Partnership between Industry and Education" (Presidential Address, Section L).

At 8 p.m.—Sir Christopher Hinton, F.R.S.: "Nuclear Power and the Engineer" (Evening Discourse).

Sunday, August 31

At 11 a.m. (in Glasgow Cathedral)—Religious Service. Preacher: The Reverend Dr. Nevile Davidson, Minister of Glasgow.

Monday, September 1

At 10 a.m.—Dr. T. E. Allibone, F.R.S.: "Some Aspects of Thermonuclear Power" (Presidential Address, Section A).

At 10 a.m.—Prof. L. R. Wager, F.R.S.: "Beneath the Earth's Crust" (Presidential Address, Section C).

At 10 a.m.—Dr. Iorwerth C. Peate: "The Study of Folk Life and Its Part in the Defence of Civilization" (Presidential Address, Section H).

At 10 a.m.—Dr. E. N. Willmer: "Some Aspects of Cellular Differentiation" (Presidential Address, Section I).

At 8 p.m.—Dr. C. F. A. Pantin, F.R.S.: "Living Machinery and the Electron Microscope" (Evening Discourse).

Wednesday, August 27—Wednesday, September 3

The Combustion Institute, in collaboration with the Institute of Fuel (at the Royal Institution of Great Britain, 21 Albemarle Street, London, W.1, and at Oxford)—Seventh International Symposium on "Combustion".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Research Assistant (with a degree in agriculture with special reference to animal husbandry or production), for investigations on carcase quality of beef—The Secretary, School of Agriculture, The University, Cambridge (September 8).

Junior Research Fellow in Geography—The Registrar, The University, Sheffield (September 13).

Lecturer/Senior Lecturer (preferably with a special interest in morphological, physiological or chemical cytology) in Histology and Embryology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, September 13).

Assistant Experimental Officer (with a degree or diploma in agriculture or botany and preferably a knowledge of potato varieties) in the Virus Diseases Section—The Secretary, Scottish Plant Breeding Station, Pentlandfield, Roslin, Midlothian (September 15).

Assistant Lecturer (with special qualifications in applied mathematics) in Mathematics—The Registrar, The University, Manchester 13 (September 15).

Lecturer in Pure Mathematics—The Registrar, The University, Hull (September 15).

Senior Lecturer or Lecturer in Physics at the University of Khartoum, Sudan—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 22).

Assistant Lecturer in Botany—The Registrar, The University, Manchester 13 (September 30).

Chair of Logic and Metaphysics—The Secretary to the Curators of Patronage, The University, 4 Albyn Place, Edinburgh 2 (September 30).

Director (academically well qualified, of proven scientific leadership and administrative ability) of the Cawthron Institute, Nelson, New Zealand, to develop researches primarily into plant nutrition problems of horticulture and agriculture—The Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, New Zealand or the N.Z. High Commissioner, 415 Strand, London, W.C.2 (New Zealand, September 30).

Lecturer in Inorganic Chemistry at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

Research Officer (preferably with a good university honours degree in physics, or mathematics, with postgraduate research experience) in the Division of Meteorological Physics, C.S.I.R.O., Aspendale, Victoria, Australia, to participate in a programme of research into the micro-meteorological aspects of various agricultural problems with special emphasis on the study of evaporation from natural surfaces—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 420/127 (September 30).

Chair of Soil Science in the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 8).

Lecturer in Psychology at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer/Senior Lecturer in Pathology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Assistant Experimental Officer (with a degree in chemistry or agricultural chemistry), to carry out chemical analyses of soils and plants—The Secretary, Rothamsted Experimental Station, Harpenden, Herts.

Assistant Lecturer (with an honours degree and interested in research work) in the Botany Section of the School of Pharmacy—The Secretary, Royal College of Science and Technology, Glasgow.

Head (with high academic qualifications in mathematics, teaching and research or industrial experience, and preferably specialized in statistics and/or numerical analysis) of the Department of Mathematics—The Principal, College of Technology, Queen Street South, Huddersfield.

Plant Pathologist (male, with a good honours degree in agriculture or natural science, at least one years postgraduate training in mycology and plant pathology, and preferably a knowledge of virus diseases) in the Department of Agriculture, Tanganyika, for field and laboratory work in the diagnosis and investigation of fungal and bacterial diseases of crop plants and the testing of control measures—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/08.

Principal Fisheries Research Officer (with a good honours degree in zoology and considerable postgraduate experience in fisheries research) with the Federation of Nigeria, to lead a small group of scientists and technicians in either sea fisheries research or inland fisheries and fish culture research—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/14/03.

▶ Research Assistant (with the B.Sc. (Special Chemistry) Degree of the University of London) in Chemistry—The Registrar, Brighton Technical College, Brighton, Sussex.

Senior Technician and other technical staff, for work upon steroid hormone assays in relation to gynaecology—The Director of the Endocrine Unit, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3.

Technician or Junior Technician in the Histopathology Department—The Director of Pathology, Chelsea Hospital for Women, Dovehouse Street, London, S.W.3.

Tsetse Officers (male, under 30, with a good honours degree in biology) in Tanganyika, for tsetse surveys and subsequently to advise on anti-tsetse measures—The Director of Recruitment ,Colonial Office, London, S.W.1, quoting BCD.63/8/022.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Universities Council for Adult Education. Report on the year 1956–1957. Pp. 27. (Bristol: W. E. Salt, Hon. Secretary and Treasurer, c/o The University, 1958.) [77

Scientific Film Association. Sixth Annual Report: A Report of the Council for the year ending March 31st, 1958. Pp. 12. (London: Scientific Film Association, 1958.) [77

Prime Numbers in Dynamic Geometry. By S. Ryzewski. Pp. 14. (Southampton: S. Ryzewski, 15 Landguard Road, 1958.) [77

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Inside Story

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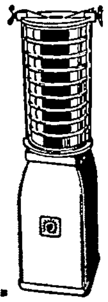

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New Books

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for the British Association for the Advancement of Science

Learning before luxury ? Should schools receive a better share of the scientists who are graduating to-day ? Science as an also-ran in girls' grammar schools ? Just one period a week of nature study for primary school science ? , How are we spending now . . . how much . . . how quickly should we expand ?

These and other topical questions on science education were discussed by certain leading industrialists, scientists, and educationalists of our day at the April, 1958, British Association Meeting. The papers now appear in eminently readable book form. They will be of interest to all who believe that the development of science and technology cannot take place without a much bolder programme of rapid educational advance than any which has yet been promulgated.

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Editor: H. M. SINCLAIR

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LECTURES AND COURSES

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

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DEPARTMENT OF CHEMISTRY
SESSION 1958-59

Head of Department: J. F. J. Dippy, D.Sc., F.R.I.C.

Recognized Day and Evening Courses leading to B.Sc. degrees (London, Internal), and the Graduateship and the Diploma (Food and Drugs) of the Royal Institute of Chemistry, commence on Monday, September 22, 1958. Various postgraduate courses are also available.

Full particulars on application to the Secretary.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY
SESSION 1958-59

A course of 20 postgraduate lectures on "Biochemistry" (to be arranged in four groups) will be given by Dr. E. M. Crook, M.Sc., and Professor F. L. Warren, M.A., D.Sc., on Mondays, 7.15 to 8.30 p.m., during the period October 6, 1958, to March 16, 1959. The course is designed for students who possess a knowledge of chemistry to degree standard. Fee: £2 for whole course or 10s. for each group.

A leaflet giving details is obtainable from the Secretary.

THE POLYTECHNIC

309 REGENT STREET, W.1
DEPARTMENT OF MATHEMATICS AND PHYSICS

The following courses of lectures have been arranged, starting in September, 1958:

1. A SECOND COURSE ON ELECTRONICS on Monday evenings, 6.30 to 8.30 p.m.
2. MODERN ELECTRIC NETWORK THEORY on Friday evenings, 7 to 9 p.m.

Full particulars may be obtained on application to the Director of Education.

UNIVERSITY COLLEGE LONDON

DEPARTMENT OF CIVIL AND MUNICIPAL ENGINEERING
COURSE IN PHOTOELASTICITY, 1958/59

This course extends over the academic year, commencing on September 29, 1958, and comprises weekly lectures on the theory and methods of photoelasticity with particular emphasis upon the use of photoelastic methods in practical stress-analysis problems. A few places are also available for students taking the course who are able to spend one or two days a week on practical work in the laboratories. The course is suitable for workers in industrial research laboratories or for teachers in engineering colleges who wish to obtain a practical knowledge of the subject. The times of lectures and laboratory periods will be arranged, as far as possible, to suit the requirements of students.

Fees: Lectures, £14. Laboratory work, 1 day per week, £11; 2 days per week, £16.

Those wishing to attend the course should make early application as laboratory accommodation is strictly limited. Application should be made to The Secretary, University College London, Gower Street, W.C.1.

OFFICIAL APPOINTMENTS

COUNCIL FOR TECHNICAL CO-OPERATION IN SOUTH AND SOUTH-EAST ASIA

Applications are invited by the Foreign Office for the following appointments at the University of Rangoon, Burma, under the Technical Co-operation Scheme of the Colombo Plan: 1. Senior Lecturer in Chemical Engineering. 2. Senior Lecturer in Metallurgy. Will be required to teach up to degree level. Should hold a higher degree in chemical engineering or metallurgy (as appropriate) and have had at least five years' teaching and research experience. Duration two years. Contract with the U.K. Government. Salary, £2,000 per annum (subject to U.K. income tax), plus tax-free oversea allowance of £1,600 per annum (less for a single man) and other allowances. Free furnished accommodation provided.

For further information and application forms, write Ministry of Labour and National Service (E.9), 26-28 King Street, London, S.W.1, quoting E9/TCS/236-7/BUR.

COUNCIL FOR TECHNICAL CO-OPERATION IN SOUTH AND SOUTH-EAST ASIA

Applications are invited by the Foreign Office for the following appointments at the University of Rangoon, Burma, under the Technical Co-operation Scheme of the Colombo Plan: 1. Lecturer in Mechanical Engineering. 2. Lecturer in Mining Geology. Should preferably hold a higher degree with, in addition, at least three years' practical experience in the case of 1. and, at least five years' field experience or three years' teaching experience, in the case of 2. 3. Lecturer in Architecture. Must have degree in Architecture or A.R.I.B.A., with at least five years' professional experience, preferably in the tropics. In all cases will be required to teach up to degree level. Duration two years. Contract with the U.K. Government. Salary £1,650 per annum (subject to U.K. income tax), plus tax-free oversea allowance of £1,360 per annum for married man (less for a single man) plus other allowances. Free furnished accommodation provided.

For further information and application form write Ministry of Labour and National Service (E.9), 26-28 King Street, London, S.W.1, quoting E9/TCS/234-5-8/BUR.

NATIONAL RESEARCH DEVELOPMENT CORPORATION

Applications are invited for the position of Managing Director of the Corporation. The Development of Inventions Acts, 1948 and 1954, under which the Corporation operates, provide for the appointment to be made by the Board of Trade. The Board will consider all applications in consultation with the Chairman of the Corporation. The appointment will be subject to the conditions set out in the National Research Development Corporation Regulations, 1949, and will run for a period of three years from April 1, 1959, in the first instance. The salary is £5,000 a year and a contributory pension scheme is available. High level administrative experience is required, together with wide knowledge of the sciences and their industrial application, or proved ability to provide administrative leadership for a technological team. Information about the Corporation can be obtained from its Annual Report published by H.M. Stationery Office, or by writing to the Secretary of the Corporation at 1 Tilney Street, W.1.

Three copies of each application, giving age, qualifications and experience, should be sent to the Secretary, Board of Trade, Horse Guards Avenue, S.W.1, before October 13, 1958, the envelope being marked "N.R.D.C. Application."

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND
LECTURER IN INORGANIC CHEMISTRY

Applications are invited for the above position. The salary range is £1,025 to £1,275, rising by £50 annual increments and the initial salary will depend on qualifications and experience. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications in New Zealand and London is September 30, 1958.

ROYAL NAVAL SCIENTIFIC SERVICE REquires Senior Scientific Officers and Scientific Officers for Establishments in London area, Baldock, Portsmouth, Portland, Poole, Greenock and Rosyth. Main requirements are about 25 vacancies for Physicists, Electronic Engineers and Mathematicians in areas specified. The following particular vacancies also exist: Mechanical Engineer for work on gas turbine problems in the London area. Mechanical Engineers for work on design and development of U/W devices in Portland area. Metallurgists for Rosyth and Poole. Chemists (Physical and Inorganic) for Poole area, Baldock and London. Candidates must normally be natural born British subjects of natural born British parents, with at least first- or second-class honours degrees or equivalent high professional attainments. Senior Scientific Officers must have had at least three years' postgraduate experience and be not less than 26 years of age. Salaries (men): Senior Scientific Officer, £1,190 to £1,410; Scientific Officer, £635 to £1,110 (London)—somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between the ages of 21 and 32 to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A98/8A.

KUMASI COLLEGE OF TECHNOLOGY

(Principal: W. E. Duncanson, Ph.D., D.Sc., F.Inst.P., A.M.I.E.E.)

Applications are invited for the posts of Senior Lecturers and Lecturers in the Department of Mechanical Engineering. The College prepares students for the London University B.Sc. degree in Engineering and for the examinations of the professional Engineering Institutions. Applicants should have a degree or equivalent qualifications with suitable teaching and professional qualifications. Duties will involve some of the following: teaching of Strength of Materials and Metallurgy, Theory and Design of Machines, Engineering Drawing; taking charge of applied Thermodynamics Laboratory. Appointment may be accepted on contract for five years or on pension or arrangements to continue policies initiated under the F.S.S.U. Scheme might be made by the College. Contract salary scales: Senior Lecturer, £2,125 by £75 to £2,425 per annum; Lecturer, £1,271 5s. by £62 10s. to £2,031 5s. plus a gratuity payable at the end of contract at the rate of £12 10s for each month of satisfactory service. Pensionable and F.S.S.U. salary scales: Senior Lecturer £1,580 by £60 to £1,940; Lecturer £925 by £50 to £1,625. Point of entry according to experience. Children's allowances up to a maximum of three at the rate of £50 per annum per child up to 10 years and £100 per annum per child over 10 years in full-time education up to 21 years. Annual leave with free return first-class passages for the member of staff and conditional on a minimum stay in West Africa, for his wife and up to three children under 17 years. Bungalows with basic furniture at low rental are provided. Income tax low.

Applications (six copies), giving age, qualifications, experience and the names of three referees, should be sent to the Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2. Closing date: September 5, 1958.

KUMASI COLLEGE OF TECHNOLOGY

(Principal: W. E. Duncanson, Ph.D., D.Sc., F.Inst.P., A.M.I.E.E.)

Applications are invited for the following appointments: (a) Senior Lecturer or Lecturer in Electric Power Machines; (b) Senior Lecturer and Lecturer in Electrical Engineering. The College prepares students for the London University B.Sc. degree in Engineering and for the examinations of the professional Engineering Institutions. Qualifications: Good honours degree; A.M.I.E.E., or equivalent professional qualification; industrial and teaching experience in the case of those applying for the Senior Lectureships. Appointment may be accepted on contract for five years or on pension. Arrangements to continue policies initiated under F.S.S.U. Scheme might be made by the College. Contract salary scales: Senior Lecturer, £2,125 by £75 to £2,425 per annum; Lecturer, £1,281 5s. by £62 10s. to £2,031 5s. per annum; plus gratuity payable at end of contract at the rate of £12 10s. for each month of satisfactory service. Pensionable and F.S.S.U. salary scales: Senior Lecturer, £1,580 by £60 to £1,940 per annum; Lecturer, £925 by £50 to £1,625 per annum. Point of entry according to experience. Children's allowances up to a maximum of three at the rate of £50 per annum per child up to 10 years, and £100 per annum per child over 10 years in full-time education up to 21 years. Annual leave with free return first-class passages for member of staff and, conditional on minimum stay in West Africa, his wife and up to three children under 17 years. Bungalows with basic furniture at low rental provided. Income tax low.

Applications (six copies), giving age, education, qualifications, experience and the names of three referees, should be sent to the Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2. Closing date September 5, 1958.

UNIVERSITY COLLEGE

IBADAN, NIGERIA

Applications are invited for Lectureship (Grade I or II) in Zoology from candidates with interests in entomology or physiology. Initial appointment three years. Salary scales: Grade I, £1,400 by £50 to £1,650 per annum; Grade II, £1,000 by £50 to £1,300 per annum. Passages paid for appointee, wife and three children under 11 years on appointment, annual overseas leave and termination. Children's, car, and outfit allowances. F.S.S.U. Part-furnished accommodation.

Detailed applications (six copies), naming three referees, by September 30, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF ELECTROTECHNOLOGY

APPOINTMENT OF PHYSICISTS

Applications are invited for appointment to one of two positions of Physicist with the Organization's Division of Electrotechnology. The Division, comprising a staff of forty scientists and thirty ancillary staff, is located in the University Grounds, Sydney, and is engaged in research in the field of electrical standards of measurement and allied subjects such as dielectrics research and microwave spectroscopy. The two positions available are: (a) Dielectrics Research. The appointee will be a member of a group of seven scientists engaged in dielectrics research. Adequate opportunity will be available for the appointee to develop an individual research programme. Applicants should possess a university honours degree in physics and some postgraduate research experience. Experience in some branch of solid state physics would be desirable. (b) Radio Frequency Measurements. Initially the appointee would be engaged on research in the frequency range 200 to 2,000 Mc./s, to develop precise power measuring techniques in the very low power range. However, ample opportunities will be given for the appointee to develop an individual research programme in precise radio frequency measurements or an allied field. Applicants should hold a university honours degree in physics with postgraduate research experience. Dependent upon qualifications and experience, commencing salary for each position will be determined within the salary ranges of Research Officer, £A.1,326 to £A.1,951 per annum or Senior Research Officer, £A.2,061 to £A.2,336 per annum. Salary for a female appointee would be £A.170 per annum, less than the corresponding male rates. Appointment will be conditional upon a satisfactory medical examination. The Appointments will be for an indefinite period or for a period of three years, at the option of the appointees. Confirmation of appointment for an indefinite period carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges. Fares to Australia, including those of wife and dependent family, will be provided by the Organization, and, in the case of appointment for a fixed period, return fares to point of origin will be allowed for an appointee who is not of Australian nationality. Details may be discussed with the undersigned.

Applications, quoting Appointment No. 760/106 and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned, from whom further particulars may be obtained, by September 26, 1958.

E. J. DRAKE,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2.

UNIVERSITY OF GLASGOW

ASSISTANTSHIP IN BOTANY

Applications are invited for an Assistantship in Botany. Salary scale: £700 to £850. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (three copies) should be lodged not later than August 30, 1958, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

UNIVERSITY OF SYDNEY

AUSTRALIA

LECTURESHIP/SENIOR LECTURESHIP IN PATHOLOGY

Applications are invited for the above position. The salary for a Senior Lecturer is within the range £A.2,200 by £A.80 to £A.2,550 per annum; for a Lecturer within the range £A.1,500 by £A.90 to £A.2,100 per annum. In each case cost of living adjustment will be allowed. The salary is subject to deduction under the State Superannuation Act. The commencing salary will be fixed according to qualifications and experience of the successful applicant. Under the Staff Members' Housing Scheme, in cases approved by the University and its Bankers, married men may be assisted by loans to purchase a house

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London, on October 31, 1958.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY

(Faculty of Technology in the University of Manchester)

RESEARCH ASSISTANT

Applications are invited for the post of Research Assistant in the Department of Physics. The person appointed will be required to take part in the research of the Department which is at present concerned with X-ray diffraction, physical optics, electronics and instrumentation, and will be expected to become a candidate for the degree of Ph.D. Applicants should, therefore, have a good honours degree in physics and some research experience, not necessarily related to the subjects mentioned above. Salary scale: £575 by £25 to £600 per annum. Superannuation under the F.S.S.U. Family allowances.

Forms of application may be obtained from the Registrar, the Manchester College of Science and Technology, Manchester 1, to whom they should be returned not later than September 20, 1958.

CHEMICAL ENGINEERING AND ATOMIC ENERGY RESEARCH

Experimentalists with experience in chemical plant operation and/or chemical engineering research are required to apply chemical engineering techniques to problems involving radioactive substances. H.N.C., or "A" level G.C.E. (including chemistry) or equivalent qualifications (preferably in chemical engineering) are required.

Salary: £420 to £855 or £990 to £1,215 depending on age and experience.

Send postcard to the Group Recruitment Officer (1184/34), U.K.A.E.A., Atomic Energy Research Establishment, Harwell, Didcot, Berks, for application form and details.

MEMORIAL UNIVERSITY OF NEWFOUNDLAND

ST. JOHN'S, NEWFOUNDLAND, CANADA

PHYSICAL CHEMIST

The Memorial University of Newfoundland invites applications from qualified persons to fill the vacant post of Assistant Professor of Chemistry, to teach Physical Chemistry up to honours degree standard. Appointments will be made for an initial period of two years and are renewable. The salary range is $5,400 to $6,000/$6,000 to $6,500/$6,500 to $7,000. Appointments may be made at a salary within the scale depending on the training and experience of the applicant. The person appointed will be eligible to join the comprehensive pension scheme, Medical Plan, and in addition will be assisted in moving to Newfoundland to a maximum of $750.

Applications should be addressed to the President, Memorial University of Newfoundland, St. John's Newfoundland, Canada, in time for appointment by September 15, 1958; two copies of application should also be sent to the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Additional particulars may be obtained from the President.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Lecturer or Assistant Lecturer in Physics to begin duties on January 1, 1959, or as soon as possible thereafter. Some experience of X-ray crystallography desirable but not essential. Salary scales: Lecturer, £900 by £50 to £1,350 by £75 to £1,650; Assistant Lecturer, £700 by £50 to £850, with F.S.S.U. provision and family allowance. Initial salary on either scale according to qualifications.

Further particulars may be obtained from the Registrar, to whom applications (four copies) should be sent by September 13, 1958.

DIRECTOR

CAWTHRON INSTITUTE, NELSON, N.Z.

Applications for the above position are invited from those who are academically well qualified, of proven scientific leadership and administrative ability, to develop researches primarily into plant nutrition problems of horticulture and agriculture. Salary scale £2,000 to £2,250.

Details are obtainable from the Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, N.Z., or the N.Z. High Commissioner, 415 Strand, London, with either of whom applications close on September 30, 1958.

GHANA PUBLIC SERVICE COMMISSION

Applications are invited for the following vacancy in the Fisheries Department. Fisheries Officer: To assist in the development of marine and freshwater fisheries; to further the use of power-driven fishing vessels and improved methods of fishing; to assist in the introduction of modern methods for the preservation and distribution of fish; to investigate scientific and technical problems relating to the fishing industry. Candidates must (1) possess a degree of a recognized university in natural science; and must be actively interested in natural history; (2) a mechanical aptitude is an advantage; (3) only male candidates are eligible for consideration. Appointment may be on pensionable or contract terms for two tours each of 18-24 months' duration. Salary £680 to £980 per annum plus overseas pay £175 to £275 a year pensionable, and £990 to £1,490 a year (including overseas pay) contract. Gratuity at the rate of £8 6s. 8d./£12 10s. for each completed month of residential service payable on completion of contract. Outfit allowance of £60 on first appointment. Free first-class passages for officer, wife and up to three children under 18 years and in addition an education allowance for children when not resident in Ghana of £100 a child for up to three children under 18 years. Generous home leave on full pay. Income tax at low local rates. Preservation of superannuation or pension rights, where applicable, can be arranged.

For further particulars and application form write, stating age, qualifications and experience, to The Director of Recruitment, Ghana High Commissioner's Office, 13 Belgrave Square, London, S.W.1.

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

TRINIDAD, T.W.I.

Applications are invited for the post of Bursar at The Imperial College of Tropical Agriculture, Trinidad, West Indies, which will become vacant early in 1959. Applicants should preferably be either qualified accountants or members of the Chartered Institute of Secretaries; or if not they should have had extensive experience of financial administration in an academic institution. The present salary scale is £1,550 by £40 to £1,750 by £50 to £1,900, the point of entry being determined by the successful applicant's qualifications and experience, but salary scales are now under review and a substantial increase is likely. The post is pensionable and carries entitlement to passages and overseas leave for the officer and his family. Unfurnished quarters will be provided at a reasonable rental.

Application forms and further details may be obtained from the Secretary, The Imperial College of Tropical Agriculture, 40 Norfolk Street, London, W.C.2. Applications must be submitted not later than October 15, 1958.

UNIVERSITY OF LEEDS

UNITED LEEDS HOSPITALS

DEPARTMENT OF MEDICAL PHYSICS

Applications are invited for the post of Physicist at a salary on the scale £625 by £25 to £700 a year, according to qualifications and experience. Candidates should have an honours degree in physics, but experience in radiation work is not essential. Duties will be concerned with problems of radiation protection and research in related fields. Facilities are available in the department for acquiring experience in the applications of physics to medicine and for preparing for a higher degree.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than September 1, 1958.

LABORATORY TECHNICIANS REQUIRED by Northern Rhodesia Government Pneumoconiosis Medical and Research Bureau for one tour of 36 months in first instance with prospect of pensionable employment. Salary scale £745 rising to £1,260 a year. Commencing salary up to £1,080 a year according to experience. Free passages. Liberal leave on full salary. N.H.S. Superannuation rights can be preserved in approved cases. Candidates aged 23 to 40, must possess Inter-I.M.L.T. and have all-round knowledge of laboratory techniques. A particular interest in biochemistry, the bacteriology of tuberculosis and histology and experience in the handling of small animals would be an advantage.—Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M.3C/44725/NF.

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

The Chemistry Department has a vacancy for an Assistant Experimental Officer to help with research work on the composition of milk, milk products, feeding stuffs, etc. Candidates should possess a suitable degree, G.C.E. with chemistry at advanced level, or equivalent qualifications. Previous analytical experience an advantage. Salary scales £370 (at age 18) to £800 (men) or £744 (women) with superannuation.

Apply, with full particulars, to the Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting reference 58/22.

WOOLWICH POLYTECHNIC

LONDON, S.E.18

Applications invited for Research Assistantships in (1) Physics, and (2) Telecommunications from honours graduates. The Assistantships will normally lead to the Ph.D. degree (Internal) of the University of London and are tenable for two to three years. Value £440 to £470 a year.

Particulars and application form from Clerk to Governors.

UNIVERSITY OF LEEDS

DEPARTMENT OF GEOGRAPHY

Applications are invited for appointment as Research Assistant in the Department of Geography at a salary of £400 a year. Candidates should have a good honours degree, a knowledge of German and ability to draw maps. Appointment for one year in the first instance, renewable; the successful candidate may apply for acceptance to study for a higher degree.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of two referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than September 8, 1958.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Botany. The salary scale is £700 to £850 per annum. Membership of F.S.S.U. and children's allowance scheme.

Applications should be sent not later than September 30, 1958, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

UNIVERSITY OF MALAYA

SINGAPORE

Applications are invited for (A) Lectureship or (B) Assistant Lectureship in Pathology from candidates with registrable medical qualifications. Salary scales: (A) £1,295 by £49 to £1,442/£1,540 by £56 to £1,988 per annum, (B) £1,148 by £49 to £1,246 per annum, entry point according to qualifications and experience. Allowances: expatriation in range £280 to £308 per annum, cost of living in range £210 to £560 per annum. Passages for appointee, wife and children under 12 years. Part-furnished quarters at reasonable rent. Provident Fund Scheme.

Detailed applications (six copies), naming three referees, by September 30, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

SCIENCE MUSEUM LIBRARY: RESEARCH Assistants. Two pensionable posts for men or women at least 22 on September 1, 1958, with (normally) University degree in an engineering or science subject and a knowledge of at least two modern foreign languages. Starting salary (men) £550 (at 22) to £685 (at 26 or over). Maximum £850. Promotion prospects.—Write, Civil Service Commission, 30 Old Burlington Street, London, W.1, for application form, quoting S.4884/58. Closing date September 16, 1958.

DEPARTMENT OF SCIENTIFIC AND INdustrial Research. Principal Scientific Officer. Pensionable post for Engineer or Physicist at least 31 on January 1, 1958, at Mechanical Engineering Research Laboratory, East Kilbride, Glasgow, to lead team carrying out research on heat transfer in a new laboratory with exceptional facilities. Qualifications normally first- or second-class honours degree in an appropriate subject or high professional attainment. Sound knowledge of basic principles and experimental techniques of heat transfer and fluid mechanics necessary. Industrial experience desirable. Salary scale (men) £1,370 to £1,950. Good housing prospects.—Write Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, for application form quoting No. S.4881/58. Closing date September 23, 1958.

UNIVERSITY OF CAPE TOWN/ PROVINCIAL ADMINISTRATION OF THE CAPE OF GOOD HOPE/ JOINT MEDICAL STAFF

LECTURER IN ANATOMY

Applications from suitably qualified persons are invited for the post of Lecturer (Grade E) in Anatomy. The appointment will be made under the terms of the Joint Staff Agreement between the University of Cape Town and the Provincial Administration of the Cape of Good Hope. The successful candidate will take part in the theoretical and practical teaching of medical students and of medical auxiliaries. The salary is £1,860 per annum plus a temporary cost of living allowance for a married man (at present £234 per annum).

Applications (with copies of testimonials), should state age, qualifications, experience, publications and research interests and give the names of two referees whom the University may consult. Two copies of the application and testimonials should reach the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (from whom memoranda giving the general conditions of appointment and further information about the work of the department of Anatomy should be obtained), not later than September 30, 1958. An additional copy should be sent direct by airmail to the Registrar, University of Cape Town, Private Bag, Rondebosch, Cape Town, South Africa. The University reserves the right to recommend the appointment of a person other than one of the applicants or else to recommend no appointment.

COLONIAL OFFICE

Applications are invited for three posts of Agronomist with the Colonial Pool of Soil Scientists based on the Macaulay Institute for Soil Research, Aberdeen, for assignment to various Colonial territories to undertake field experimentation following soil survey. Candidates should have a good honours degree in science or in agriculture with botany and chemistry. Field experimentation experience would be an advantage. Salary according to qualifications and experience, in the Scientific Officer (£615 to £1,080) or Senior Scientific Officer (£1,160 to £1,370) National salary scale plus additional allowances when overseas.

Application forms and further information obtainable from Colonial Office, London, S.W.1, quoting RES.308/01.

COVENTRY EDUCATION COMMITTEE

COVENTRY TECHNICAL COLLEGE

Laboratory Steward required for Chemistry and Biology Laboratories. Some knowledge of chemistry and experience of handling scientific apparatus desirable. Wages 4s. 5½d. to 5s. per 44 hour week, plus a working bonus of 11s. All employees expected to belong to appropriate trade union.

Application forms and conditions of appointment from the Director of Education, New Council Offices, Earl Street, Coventry.

UNIVERSITY OF SOUTHAMPTON, ZOOlogy Department. Research Assistant required as from September 1, 1958, to investigate effects of chemical pollutants on marine organisms (under Grant from Atomic Energy Authority). Good degree in chemistry or biochemistry essential. Some research experience or qualification preferable. Maximum salary £600 according to qualifications. —Applications, including names of two referees, to reach the Professor of Zoology not later than September 6, 1958. Further particulars may be obtained from the Secretary and Registrar, University of Southampton.

THE BRITISH SOCIETY FOR RESEARCH in Agricultural Engineering requires Physicists or Engineers in the following departments: Glasshouse (C.1) for design and development of environmental control for plant research purposes. Modern techniques will be used and interest in one or more of the following subjects would be useful, viz., light and radiation, heat transfer, air conditioning, transparent plastics. Instrumentation (Inst. 1) to take part in development of measurement and control equipment for wide range of applications in research and testing. Mechanical Engineering (M.E.1) for research and development in connection with tractors. Candidates must have first- or second-class honours degree and those who have completed degree in 1958 will be considered. Salary scales: As for Scientific Officer or Senior Scientific Officer in Scientific Civil Service, £595 to £1,050 or £1,130 to £1,330. Five-day week, F.S.S.U.—Application forms from Secretary, N.I.A.E., Wrest Park, Silsoe, Beds., quoting above reference numbers.

UNIVERSITY OF TASMANIA

AUSTRALIA

LECTURER IN PSYCHOLOGY

The University invites applications for the above position. The Lecturer will be required to work mainly in the field of experimental psychology but capacity to undertake work in other branches would be an advantage. The salary scales for lecturers are Grade II £A.1,450 by £A.60 to £A.1,630, and Grade I £A.1,630 by £A.60 to £A.2,050. Appointment will be offered within the range for Lecturers Grade II or Grade I according to qualifications and experience. An allowance is made towards travelling expenses and housing assistance is available.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications in Australia and London, is October 31, 1958.

UNIVERSITY OF QUEENSLAND

AUSTRALIA

SENIOR LECTURER IN PHYSIOLOGY (ANIMAL)

Applications are invited for the above position. Applicants should possess a veterinary qualification or a degree in science, and should have research experience in comparative or general physiology preferably with knowledge of and experience with domestic livestock. A biochemical or pharmacological approach to comparative or veterinary physiology would be acceptable. Opportunities exist for investigations involving neuromuscular, endocrine, or environmental (heat and light) physiology. Salary £A.2,160/£A.2,510.

Further particulars and application forms are obtainable from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in London and Australia, on October 15, 1958.

VICTORIA UNIVERSITY OF WELLINGTON

NEW ZEALAND

SENIOR LECTURER IN MATHEMATICS

Applications are invited for the above position. The salary will be £1,315 per annum rising by annual increments of £50 to £1.615. The initial salary will be determined according to the qualifications and experience of the appointee. An allowance is made towards travelling expenses.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications, in New Zealand and London, is October 31, 1958.

UNIVERSITY OF WESTERN AUSTRALIA

CHAIR OF SOIL SCIENCE

Applications are invited for this newly created Chair in the Institute of Agriculture. The salary will be £A.3,500 per annum. An allowance is made towards travelling expenses and housing assistance is available.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close, in Australia and London on October 8, 1958.

D.S.I.R. FIRE RESEARCH STATION, BOREham Wood, Herts, requires Scientific Officer for work on growth and spread of fire and associated combustion and fluid flow problems. Qualifications: first- or second-class honours degree, in physics, chemistry or engineering. Salary range: (men), £595 to £1,050. Allowance for National Service and postgraduate experience. Normal prospects of promotion in mid-thirties to Principal Scientific Officer. (Salary range £1,370 to £1.950.) —Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quote A.312/8A). Closing date September 20, 1958.

JUNIOR TECHNICIAN (PREFERABLY male, age between 15 and 16 years) required for the Department of Zoology, University of Edinburgh.—Applications, stating age, qualifications and experience, to be sent to the Secretary to the University, Old College, South Bridge, Edinburgh, not later than September 1, 1958, quoting Reference Z/JT/8/58.

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

BURTON STREET, NOTTINGHAM

Principal: D. A. R. Clark, M.Sc.(Tech.), M.I.Mech.E.

Applications are invited for the full-time appointment of Assistant, Grade B, in General Chemistry. A large new building comes into use in September next for well-equipped Departments of Building and Civil Engineering, Electrical Engineering, Chemistry, Physics and Mathematics, and Mining. Increased accommodation is also available to the Departments of Mechanical Engineering, Arts and Commerce, Printing and Textiles. Research work by both staff and students is being rapidly developed. Experience in industry, teaching and/or research desirable. Salary in accordance with the Burnham Technical Scale as follows: £650 by £25 to £1,025 per annum. Additions include degree allowance of £75 per annum (or £125 for good honours degree), up to three increments of £25 for training in approved cases and incremental allowance for industrial experience after age 21, and war service.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than September 6, 1958.

CENTRAL ELECTRICITY GENERATING BOARD

Require HEALTH PHYSICISTS for Nuclear Power Stations at Bradwell (Essex) and Berkeley (Glos.). Successful candidates will have responsibility for radiological measurements in and around the station to which they are appointed and for personnel safety. Good scientific qualifications are required, preferably of degree standard, and some industrial experience in a responsible position would be an advantage. Specialized knowledge of health physics is not essential as the successful candidates will be given an adequate course of training, expected to begin in November, 1958, and last approximately nine months. Salaries within range £1,560 to £1,665 per annum.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to I. G. Ellis, Personnel Officer, 24/30 Holborn, London, E.C.1, by September 1. Please mark envelopes "Confidential" and quote ref. N/241.

COMMONWEALTH BUREAU OF HELMINTHOLOGY

THE WHITE HOUSE,
103 ST. PETER'S STREET, ST. ALBANS, HERTS

Scientific Assistant required for work in scientific information service involving abstracting and indexing. Good science degree, reading knowledge of two European languages (preferably other than French or German) and ability to write good English essential. Knowledge of helminthology an advantage. Salary scale £595 to £970 (bar) to £1,330 (bar) to £1,460. Age, qualifications and experience considered when fixing starting salary. Up to two increments for compulsory National Service and two extra increments on completing two years' satisfactory service if aged 32 and under. Superannuation according to F.S.S.U.

Applications, stating age, qualifications and experience, together with names of three referees, should be sent to the Director before September 30, 1958.

UNIVERSITY OF GLASGOW

LECTURESHIP OR ASSISTANTSHIP IN AGRICULTURAL BOTANY

Applications are invited for a Lectureship or Assistantship in Agricultural Botany. Salary scale: Lecturers, £900 to £1,650; Assistants, £700 to £850. Initial salary according to experience and qualifications. F.S.S.U. and family allowance benefits.

Applications (eight copies) should be lodged not later than August 30, 1958, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
Secretary of University Court.

RUCHILL HOSPITAL

GLASGOW, N.W.
VIRUS LABORATORY

Honours science graduate required for virus work in tissue culture. Previous experience not essential. Salary on Whitley scale for biochemists and physicists range £625 to £1,000 according to experience.

Applications by September 15 to the Physician Superintendent.

WESTERN REGION OF NIGERIA

DEPARTMENT OF AGRICULTURE
SOIL SCIENTIST (ANALYST)

To carry out soil analyses and nutritional studies of cocoa and annual crops as a member of a team. In addition will probably be required to take over, for limited periods, the general duties of an agricultural chemist. Candidates must have a good honours degree in chemistry (or equivalent) and should have had one or two years suitable postgraduate training or experience. Appointment on contract/gratuity terms with emoluments in scale £1,086 to £1,944 per annum. Gratuity of £37 10s. is payable for each completed period of three months' satisfactory service. Outfit allowance £60. Free passages on appointment and leave for officer, wife and up to three children under 13 years of age. Furnished quarters at moderate rental. Generous leave.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/410/015.

GAMBIA

LIVESTOCK IMPROVEMENT OFFICER

To investigate fodder resources and subsequently initiate a programme of work designed to establish a mixed farming system of agriculture. Candidates must have a university degree in agriculture and considerable knowledge and experience of crop and animal husbandry. Appointment on contract/gratuity terms with salary in scale £1,212 to £1,842 per annum. Gratuity £37 10s. for each completed period of three months' service (including leave). Quarters at low rental. Free return passages for officer, wife and up to two children. Generous leave.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/013.

NORTHERN REGION

NIGERIA

Entomologist required in the Veterinary Department of Northern Nigeria. Duties involve tsetse surveys and identification of species; field observation on seasonal distribution and habits of tsetse flies, particularly *Glossina morsitans*; and duties in connection with the control of the species. Candidates must possess a natural science degree from a British university and preferably a knowledge of tsetse, particularly *Glossina morsitans*. Appointment may be (a) on three years probation for permanent and pensionable employment. Pension (non-contributory) at rate of 1/600th of final pensionable emoluments for each completed month of reckonable service. Salary in scale £804 to £1,950 a year; or (b) on short-term contract (two tours each of 18 to 24 months) with salary of £870 to £2,118, and gratuity (taxable) of £37 10s. for each completed period of three months service (including leave). Starting salary in both cases depends on qualifications and experience. Quarters provided at low rental. Taxes at local rates. Annual leave permissible; generous home leave granted after each tour. Free passages in both directions for officer and wife; assisted passages for children. Allowances for children of £120 a year for first child, £96 for second and £72 for third.

Application forms from Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.67/408/015.

BRISTOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY
SCHOOL OF PHARMACY
ASSISTANT LECTURER, GRADE B, IN PHARMACEUTICAL SUBJECTS

Governors invite applications for this full-time post, vacant September 1, 1959. Candidates should have degree in pharmacy or pharmaceutical qualification. Teaching, research or industrial experience an advantage but not essential, and recent successful entrants to final examinations now having postgraduate training may apply. Burnham Technical Scale salary: men, £650 by £25 to £1,025; women, £580 by £20 to £820, plus equal pay increments. Additions for degree and training and where applicable increments for approved industrial experience.

Details and application forms from Registrar, College of Technology, Bristol, 7.

MEDICAL RESEARCH COUNCIL REQUIRE a Senior Technician at the Department of Experimental Medicine, Cambridge. General physiological and biochemical laboratory experience essential. Salary on scale £620 to £760 or £660 to £840 per annum. Four weeks' annual leave. Superannuation provision.—Write, giving full particulars, to the Director, Department of Experimental Medicine, 5 Shaftesbury Road, Cambridge.

SENIOR EXPERIMENTAL OFFICER

and

EXPERIMENTAL OFFICER

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS.

Post 1 (Ref. 1963/34)

The post carries responsibility for the construction of high energy condenser banks designed to produce very heavy current gas discharges. Duties include development and construction of the banks, design of high voltage low inductance switching systems, development of oscillographic methods of measuring the performance of the banks and supervision of technical staff.

Pass degree, H.N.C., or equivalent qualification required. Familiarity with high voltage laboratory techniques and pulse circuitry essential. Candidates should be at least 35 years of age.

Salary: £1,360 to £1,630 per annum.

Post 2 (Ref. 1990/34)

To assist in experimental work designed to assess the hazards of handling high explosives. Duties will include development work on dust extraction equipment. Applicants, who should be at least 26 years of age, must be prepared to travel to Outstations and to work in the open.

H.N.C. in appropriate subject required, but applicants with H.S.C. or G.C.E. in five subjects including English language at "O" level, and two scientific or mathematical subjects at "A" level, will also be considered.

Some experience of handling high explosives would be desirable, and experience of dust control methods or machine shop practice would be an advantage.

An ability to design and construct experimental apparatus is required.

Salary: £990 to £1,215 per annum.

Contributory Superannuation Scheme. A house, or assistance towards legal expenses on house purchase, will become available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at above address. Please quote appropriate reference number.

ADEN

FISHERIES OFFICER

To organize and develop the domestic fisheries of the Colony and Protectorate. Candidates, male, must have a university degree in Natural Science (Zoology) and preferably some experience of fishery administration. Appointment on probation to the permanent establishment with pensionable emoluments in range £1,032 to £1,929 per annum, or on contract/gratuity terms. Gratuity at the rate of £25 to £37 10s. for each completed period of three months' service. Free passages on appointment and leave for officer, wife and up to four children. Furnished quarters normally available at moderate rental. Outfit allowance on first appointment.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/2/01.

MID-ESSEX TECHNICAL COLLEGE AND SCHOOL OF ART

MARKET ROAD, CHELMSFORD

Required as soon as possible, Laboratory Technician. Preference will be given to candidates who are qualified as Instrument-makers or Physics Technicians. Duties include supervision of work of Science Laboratory Staff. Salary: Grade IV for Miscellaneous Classes of Officers: £565 by £20 to £625.

Further particulars and forms of application from the Clerk to the Governors.

MEDICAL LABORATORY TECHNICIAN. Vacancy will occur end of August. Qualified A.I.M.L.T., science degree or equivalent. Whitley conditions.—Apply, in writing, to Administrative Officer, North London Blood Transfusion Centre, Deansbrook Road, Edgware, Middlesex.

UNIVERSITY OF OTAGO
DUNEDIN, NEW ZEALAND
SENIOR LECTURER OR LECTURER IN MATHEMATICS

Applications are invited for this position. Salary range: Senior Lecturer, £1,315 by £50 to £1,615 per annum; Lecturer, £1,025 by £50 to £1,275 per annum.

Further particulars are available from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. Applications close in London and New Zealand on September 30, 1958.

RESEARCH FELLOWSHIPS IN GOVERNMENT Scientific Establishments: Senior and Junior Research Fellowships, tenable for three years, in a very wide range of subjects. Qualifications: normally first- or second-class honours degree and evidence of a very high standard of ability in research. At least two years' postgraduate experience expected for Junior Fellowships (three years for Senior Fellowships). Rates £1,100 to £1,350 for Senior Fellowships and £750 to £1,000 for Junior Fellowships. F.S.S.U. applies.—Write Civil Service Commission, Scientific Branch, 30 Old Burlington Street, London, W.1, for application form, quoting S.4798/58.

NATIONAL PHYSICAL LABORATORY, Teddington, Middlesex, has vacancies in Applied Physics, Basic Physics, Light, Mathematics, Metallurgy, and Standards Divisions. Qualifications: first- or second-class honours degree or equivalent in appropriate subject. Postgraduate research experience an advantage. Posts unestablished with possibility of establishment whilst under age 31. Salary: Scientific Officer, £635 to £1,110. Senior Scientific Officer, £1,190 to £1,410 (men). Women slightly less.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting Ref. No. A.135/8A.

APPOINTMENTS VACANT

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"Where σ is stress, *p* is density and V is particle velocity . . ."

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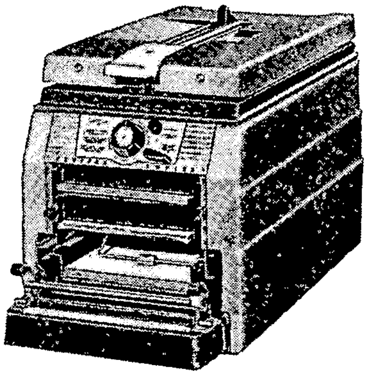

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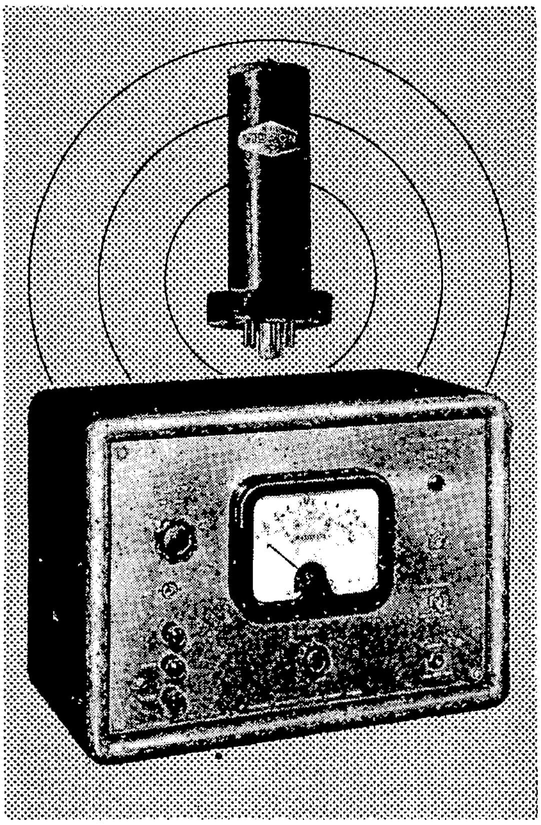

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SCIENCE, BUSINESS AND EDUCATION

TWENTY-SIX years ago, the papers read to the Department of Industrial Co-operation (a group within Section F) at the centenary meeting of the British Association were published under the title "Business and Science". The main emphasis in these papers is on management, but a glance at their titles in the context of automation and other subsequent developments shows the prescience of the organizers of that gathering. Sir Alexander Fleck borrows the title of the volume for his presidential address at the Glasgow meeting of the Association (see p. 573 of this issue of *Nature*). To some it may appear that his address is platitudinous; but the charge is unjustified. Some familiar truths are indeed re-stated, but there are others, notably in regard to the nature of business activity, which badly needed to be re-stated and are more often disregarded than put into effect.

Sir Alexander, however, adds to his title the words "A Balanced Partnership", and in doing so displays the quality that gives his address its distinctive character and value. Disclaiming any intimate acquaintance with the practice of particular disciplines, he speaks, much as the late Lord Stamp spoke at Blackpool, as one who, himself trained as a scientist and understanding the framework within which scientific thought develops, is also familiar with the outlook and problems which confront the business or industrial administrator who is concerned to make generally available the services or goods which scientific and technical knowledge can provide. In that connexion it is pertinent to recall that, when last November the Prime Minister announced his choice of Sir Alexander Fleck to preside over the three committees of inquiry into the accident at Windscale, Mr. Macmillan gave as the decisive reason his belief that in the highly technical aspects of the accident Sir Alexander had sufficient scientific knowledge of a general character.

Whatever so-called platitudes this address may contain, they are re-stated with the clarity to be expected of one whose recognition of the importance of clear exposition and vivid interpretation is well known, and with the balance and perspective which are often derived from the simultaneous study of science and history which once again Sir Alexander advocates in this address. But above all they are emphasized by the wealth of experience and the sound judgment which have frequently marked Sir Alexander as pre-eminently the man to fill some particular post where understanding of both science and public affairs is required.

This note of authority sufficiently refutes any real thought of platitude; but there is a further reason which gives particular interest to a presidential address quite distinct from those of most of his predecessors. In itself, it demonstrates the decisive importance of both a balanced outlook and a balanced education in order to achieve that partnership of science and business which Sir Alexander regards as fundamental, and especially a balanced relation between science and government which is no less essential. As Sir Alexander observes, if science is to further our social evolution, it needs the financial and productive effort of business, while no less fundamentally, the prosperity of Great Britain depends on the technologically sophisticated products of our export trade.

Sir Alexander devotes about half his address to indicating how this balanced partnership between science and business can be achieved; but his suggestions are concentrated mainly on the place of the scientist in the business structure and on the achievement of balance in education. What Sir Alexander says about the functions of the scientist in business indeed leads up to and underlines the necessity for balance in education, for the avoidance of premature specialization, the formation of character and the development of intellect and personality. He recognizes indeed that education must to some extent aim at providing useful members of society, and he does not believe that to do so—even in the universities—is completely contrary to the British tradition of individual liberty. But while in framing our formal education we cannot entirely ignore the requirements of the society in which that educational system exists, he points out that that society will not be tolerable to live in if its members are not permitted to develop their personalities and talents.

This respect for the desires and personality of the individual also pervades Sir Alexander's brief survey of the functions and opportunities of the scientist in business. He stresses the importance of research and illustrates the way it functions, the dependence upon team-work between specialists in varied scientific disciplines, the distinction between research and development and the functions of design and construction. All this is set forth with lucidity and authority; but Sir Alexander is no less emphatic and convincing in showing how the scientific mind has its essential part to play in production and in the commercial departments, as well as at the level of management and higher administration. Moreover, that contribution cannot be rendered without flexibility and adaptability of mind, as well as breadth of experience. While it is to be hoped that due note will be taken in the appropriate quarters of the importance of scientists infiltrating almost the whole business structure, so that at every administrative level there are those competent to assess for themselves technological or scientific advice, it is no less desirable that scientists themselves should appreciate what Sir Alexander says about the way in which they can fit themselves for high responsibility.

The balance we seek must come in large measure, in Sir Alexander's view, from within the individual himself, derived from the education which the scientist and the non-scientist should receive. Once again he stresses the need for those who study the humanities to have some understanding of the workings of science, and for the scientist to be able to relate his science to its human context both historically and in terms of the present day. Ultimately, it is on this process that Sir Alexander relies to ensure that full use is made of the scientist in business, both by giving his powers full scope and by fitting him for wider responsibilities and more varied duties.

On that note, that a truly balanced partnership of science and business will manifest itself in the growing use of science and its methods in business, and that such a partnership can only come from a balanced education for scientists and business-men alike—with the reminder that the society which such a partnership can help to build will always require courage, integrity and tenacity—Sir Alexander closes. He himself would be the first to disclaim any novelty for his ideas. In one form or another they have been repeatedly urged in the post-war period, though never with greater cogency. We may well be grateful that they have again been set forth so lucidly from the presidential chair of the British Association by one who speaks with the authority and experience which Sir Alexander can command.

Nor need we be pessimistic as to their effect. It is more than twenty years since the late Lord Stamp, also in a presidential address to the British Association, examined the impact of science upon society and, touching on cultural lags in a dynamic society, approached this question of balance at a different angle. Lord Stamp's address displayed the same sense of responsibility on the part of business as does Sir Alexander's, but he said little or nothing about the vital question of education, and his remarks about the scientific worker in a wider field lacked the incisiveness of Sir Alexander's. In the interval, the question of education has come to the front, and there are few things more encouraging than the growing recognition, especially in the past few years, of the vital importance of a balanced education. We have still to reach agreement as to the way or ways in which such an education can be provided, though some notable leads have been given in recent months. Sir Alexander's address will bring a new sense of urgency and inspire the co-operation and understanding that are essential for the sustained effort which he himself recognizes as the true line of advance.

SIR GEOFFREY TAYLOR'S WORK ON THE MECHANICS OF SOLIDS

The Scientific Papers of Sir Geoffrey Ingram Taylor
Edited by Dr. G. K. Batchelor. Vol. 1: Mechanics of Solids. Pp. x+593. (Cambridge: At the University Press, 1958.) 75*s*. net.

IT was an excellent idea to publish in collected form the scientific papers of Sir Geoffrey Taylor, papers which have done so much to establish our modern views on the mechanics of real materials. When Sir Geoffrey began his researches about forty-five years ago the only serious attempt that then existed to understand the mechanical properties of matter in terms of atomic structure was the kinetic theory of gases; and this theory could say scarcely anything about the turbulent motion which is man's oldest and most familiar experience of the mechanics of gases. Practically nothing was understood about solids and liquids. Apart from a few theorems on the elasticity of crystals, both these states of matter were discussed by analogy with hypothetical continuous media which had certain ideal properties. The laws of these media owed nothing to the particulate structure of matter, and the things they predicted were often so different from what occurred in real materials that the subject was no longer regarded as physics but applied mathematics. Even within the framework of these idealized laws, many problems remained unsolved. Turbulent flow, for example, was scarcely less difficult for the theory of ideal liquids than for the kinetic theory of gases. As for calculating the viscosity of water from first principles, or understanding why a piece of copper wire stretches a certain amount and then breaks at a certain stress when pulled at its ends, such things were quite out of question. This part of the subject seemed so unapproachable that at least one distinguished scientist ventured the opinion "ignorabimus" about it.

Although it deals only with solids—the papers on fluids are to appear in three other volumes—this first volume of Sir Geoffrey's papers shows most fascinatingly how the science of the mechanical properties of matter has become transformed over the past forty years and how this transformation has been brought about mainly by these papers themselves. The first three papers, published jointly with A. A. Griffith in 1917–18, describe the famous method for solving problems of torsion in elasticity by the use of soap films, whereas the last paper, which was read in Madrid at a conference in 1955, contrasts plastic slip in body-centred cubic and face-centred cubic crystals, and develops from this contrast a theory of why polycrystalline iron differs from metals such as aluminium and copper in its plastic properties. What a striking development of the subject this represents! Here one is dealing with plastic slip in real crystals, taking full account of the crystal structure and its influence on the slip process, distinguishing between one metal and another, and at the same time taking full account of the polycrystalline structure of the material and the effects of intercrystalline boundaries.

The forty or so papers that have made this possible are all set out in this volume, and they include several that were written originally for Government departments or advisory committees and are published here for the first time. Those familiar with the subject will enjoy being reminded of all the branches that were pioneered by Sir Geoffrey's work; for example, the early papers with Miss Elam that established the crystallographic laws of slip in metals; the papers on stored energy in cold-worked metals; the famous paper written in 1934 on dislocations, the theory of which was foreshadowed in another of Sir Geoffrey's papers published by the Faraday Society in 1928; the paper in 1938 which showed for the first time how to deal mathematically with the plastic deformation of polycrystalline aggregates; the papers on plastic waves and effects of shock loading; and the papers on the laws of plastic deformation under combined stresses. Those new to the subject will find in these papers an introduction which, for originality, clarity, enjoyment, enthusiasm, and authority, could not be better. The editor of this volume, Dr. G. K. Batchelor, and its sponsors, the Ministry of Supply and Trinity College, Cambridge, are to be congratulated on their valuable enterprise. A. H. COTTRELL

NUCLEAR PHYSICS AND ATOM BOMBS

Brighter Than a Thousand Suns

The Moral and Political History of the Atomic Scientists. By Dr. Robert Jungk. Translated into English by James Cleugh. Pp. 350. (London: Victor Gollancz, Ltd., in association with Rupert Hart-Davis, Ltd., 1958.) 21*s.* net.

DR. ROBERT JUNGK attempts in this book to write "The Moral and Political History of the Atomic Scientists" or "the inside story behind the construction of the atomic and hydrogen bombs". The story is written largely around personalities, including Rutherford, Bohr, Heisenberg, Joliot-Curie, Kapitza, Fermi, Oppenheimer, Szilard and Teller. The author has obtained his knowledge at second hand by diligent inquiry from a galaxy of scientists whose help is acknowledged in the introduction.

The story opens with Rutherford's disintegration of nitrogen by α-particles and rapidly switches to Göttingen to describe the life of the scientific notables of the day—Born, Frank, Klein, Heisenberg and Hilbert, with their numerous visitors, including Bohr, Blackett, Dirac, Oppenheimer and Pauli. It describes the dismissal of the seven Jewish professors from Göttingen, including Max Born and Courant, after Hitler's seizure of power, and follows this with a sympathetic account of Niels Bohr's Institute of Theoretical Physics in Copenhagen, referring to his "Castle of Carlsberg" and an amusing parody of Faust in which Bohr and Pauli were principal characters.

From here the story turns to Cambridge, where a highly inaccurate account of the Cavendish Laboratory is given. The nuclear physicists, including Blackett, Oliphant, Feather and myself, are said to have worked as a kind of "subordinate section" directed by Kapitza. He refers also to Kapitza's "baby giants of high voltage". Nothing could be farther from the truth, for Kapitza took no part in experimental nuclear physics at this time. Kapitza's detention in the U.S.S.R. in 1934 is said to have had "a disruptive effect on the Cavendish as a whole" and "Rutherford's own mighty frame suddenly began to age". This again is more fiction than fact.

The narrative then moves to Rome and Fermi's work on the production of radioactivity by neutrons. The author discusses why fission was not discovered in these experiments, and suggests that physicists did not appreciate that neutrons might be able to penetrate the potential barrier of heavy elements. Since Fermi was producing radioactivity in many heavy elements this is nonsense. What the physicists and chemists failed for so long to realize was that processes other than the emission of protons, α-particles and electrons could take place. There is also an account of supposed friction between Madame Joliot and Madame Meitner resulting from the Solvay Conference of 1933. The discussions are reported verbatim in the Solvay Conference Papers and do not support this. These early chapters do not therefore provide high marks for the author's credibility or scientific knowledge.

After this the story goes on to the discovery of fission and thereafter to the war years and the 'uranium project' in Germany, which was directed entirely to producing a heavy water atomic pile and never to produce an atomic bomb. The narrator gives an account of discussions between Houtermans and Weizäcker in 1941, in which he states that the two agreed that the first and most important task of uranium policy must be to keep departments in the dark about the now imminent feasibility of manufacturing such bombs. The author's general thesis about the German atomic energy project is contrary to the conclusions of Goudsmit in "Alsos".

After this the story moves to the United States, to describe the origin of the atomic project in that country and the development of the Manhattan project, and then devotes two chapters to Oppenheimer's founding of Los Alamos and the development of the atomic bomb.

The author then gives an account of the discussions as to whether and how the atomic bomb should be used and describes the labours of the United States 'Interim Committee' which had to advise the President on this question. The Interim Committee had a scientific panel consisting of Oppenheimer, Fermi, A. H. Compton and E. O. Lawrence. These discussions have been described in much more detail and from first-hand knowledge in A. H. Compton's book "An Atomic Quest". Opinion on the scientific panel was divided as to whether and how the bomb should be used. There were similarly divided views among the staffs of the Chicago laboratories. However, the doubts of the scientists produced little effect, and Mr. Stimson, Secretary for War, has given his own account of the reasons, based on potential loss of American lives, which led him to advise that the bomb should be used. Dr. Jungk records General Grove's view that President Truman did "not so much say yes as not say no".

The story moves on to the years of McCarthyism in the United States and the investigation of Robert Oppenheimer. It retells the now familiar story of the debates as to whether the United States should develop the hydrogen bomb.

One chapter of the book is devoted to the Fuchs case. The author makes the remarkable and ridiculous suggestion that the Russians might have denounced Fuchs to the British Intelligence Service to upset Anglo-American relations.

The author concludes that these events have forced physicists to leave their 'ivory towers' and to be made aware of their responsibilities to the world.

The book as a whole is interesting, but it cannot be considered as an accurate historical account of these developments. JOHN COCKCROFT

CO-OPERATIVE PHENOMENA

Changes of State

A Mathematical-Physical Assessment. By H. N. V. Temperley. Pp. xi+324. (London: Cleaver-Hume Press, Ltd., 1956.) 50*s.* net.

THE term 'changes of state' would usually be taken to imply primarily the processes of fusion and evaporation for which, typically, the transition temperature is sharply defined. There are, however, many other changes of state which proceed more gradually as the temperature changes; and a 'critical temperature' may be associated not with a latent heat but with, for example, a discontinuity in the specific heat. "Until comparatively recent times", the author says, "the underlying similarities of all changes of state have not been realised". In this volume, he directs attention to the formal similarities, and discusses fully the individual peculiarities. After a short historical introduction, he classifies the various types of change from a thermodynamic point of view, gives a general account of basic theoretical considerations, and then surveys in detail the main fields in which changes of state are involved. Successive chapters deal with evaporation, fusion, solutions and order–disorder phenomena, ferromagnetism and antiferromagnetism, ferroelectricity, superconductivity, and the transition of liquid helium.

The author deals mainly with the development of interpretative descriptions of collective behaviour, using justifiable or plausible 'models', that is, essentially, assumed types of interaction between atoms or molecules. He is not usually concerned with precise comparisons with experiment, for the models which can be fully worked out are so idealized that, he says, "the emergence of a theoretical curve passing through the experimental points is not *quite* the occasion for rejoicing that it is in other branches of physics". The book is thus essentially theoretical. It is not heavily mathematical in form, except for occasional outbursts, but a clear understanding of the often complex mathematics involved underlies many of the accounts given in words of the theoretical treatments.

Only a small part of the book deals directly with changes of state, either generally or specifically. Indeed, once an atomic and statistical mechanical treatment is embarked upon, the theory of changes of state cannot be isolated from the theory of the characteristics of the 'phases' between which transitions occur. The main bulk of the book consists of concentrated surveys of some of the most difficult, complex, and controversial problems of theoretical physics arising in the treatment of such co-operative phenomena as those of ferromagnetism and superconductivity.

It is impossible in a short review to do justice to the author's vast range of reading, to his penetrating critical powers, and to the care he has taken in incorporating in a personal assessment a balanced survey of the complementary, or sometimes contradictory, theoretical treatments which have been given of the various phenomena. There are few readers who will not find on almost every page some novel and thought-provoking comment or suggestion.

In spite of the author's own clear-headedness, and the lucidity of his exposition of so many difficult pieces of theory, the book makes very formidable demands on the reader. Most of the chapters are in effect concentrated monographs, but they are not sufficiently independent for separate reading. For a proper appreciation of one of these chapters the reader must have in mind not only the opening chapters of the book but also sections embedded in other earlier chapters and often in later ones, too. Above all, however, bearing in mind that this is a book intended "to help actual and potential research workers to 'find their way around' this fascinating but complicated field", the main issues tend to be confused by the packing in of details which could be fitly accommodated only in specialized treatises of more restricted range.

It may be that the book has just grown from a consideration of changes of state, but after the event a more informative title might have been devised, perhaps including the words 'co-operative phenomena'. The field is almost coterminous with that of the physics of matter, and is of immense importance. There is no other single account of the theoretical aspects as comprehensive as that given here. The journey through the book is difficult, but it is to be hoped that many will face its ardours; they will be richly rewarded. E. C. STONER

RUSSIAN ASTROPHYSICS

Theoretical Astrophysics

Edited by V. A. Ambartsumyan. Translated from the Russian by J. B. Sykes. Pp. xii + 645. (London: Pergamon Press, Ltd., 1958.) 135*s*.

THIS book is a translation of a well-known Russian text-book, a co-operative work by five authors, E. R. Mustel, V. V. Sobolev, A. B. Severnyi, S. B. Pikel'ner, and V. A. Ambartsumyan, who also acted as general editor. The Russian version appeared in 1952 and few corrections or additions have been made for this English edition, although an editorial preface rather ruefully comments on the difficulties created by the very rapid development of astrophysics in recent years.

The reader will find a thorough treatment of those parts of the subject which were the centre of attention between the Wars, but little on other branches which have grown so spectacularly during the past ten or fifteen years. The development of new photometric methods and of radio astronomy, and the application of electronic computers to the internal structure of stars, have led recently to a concentration on problems of galactic structure, of interstellar matter, of star populations and stellar evolution, and have also revived interest in the older techniques of astrometry, radial velocities, etc. Little of these subjects appears here. This is understandable enough and scarcely a cause for complaint, but I would have preferred the book to have had a less general title, giving a more precise indication of the contents. A comprehensive account of theoretical astrophysics is to-day beyond the powers of one author and beyond the capacity of any ordinary text-book, while rapid growth and change make early obsolescence almost inevitable. These are very real and serious difficulties, in whatever language the book may be written.

Sixteen chapters, about half the book, are devoted to the problems of stellar atmospheres, especially the theory of radiative equilibrium, the formation of continuous spectra, Fraunhofer lines, etc. There are six informative chapters on the outer layers of the Sun, including a welcome introduction to the electrodynamic problems which are to-day of such great importance. There are three chapters on planetary nebulæ, two on novæ, and two on stars with bright-line spectra. There are three brief chapters dealing with the internal constitution of stars, confined mainly to the earlier, classical theory. There are also two chapters on the scattering of light in planetary atmospheres and two on interstellar matter.

The book is slightly more elementary than Unsöld's "Theorie der Sternatmosphären". It is a welcome addition to the comparatively few general texts of solid worth which are now available, and Western readers will find it interesting, too, as an indication of the method of approach adopted for Russian students. Although there are differences of detail, on the whole the treatment is very similar to what would be expected in any good work from Western Europe or the United States. There is a natural tendency to refer to Russian authors in preference to others. In some ways this is a healthy check to Western complacency, but there are some slightly surprising omissions. For example, Hertzsprung does not appear in the index and the cinematography of prominences is discussed without Lyot.

The translation appears to be good and there are few misprints. R. O. REDMAN

ADVANCE OF CHEMICAL TECHNOLOGY

Encyclopedia of Chemical Technology

Edited by Raymond E. Kirk and Donald F. Othmer. First Supplement Volume. Pp. xvii+974. (New York: Interscience Encyclopedia, Inc., 1957. Distributed by Interscience Publishers, Inc.; London: Interscience Publishers, Ltd.) 25 dollars.

IT is more than ten years since the first volume of Kirk and Othmer's "Encyclopedia of Chemical Technology" appeared. Volume 15, which appeared in 1956, brought the alphabet to its end. That volume was reviewed in *Nature* (179, 983, 1957). I expressed satisfaction then that it had been decided to issue a supplementary volume, because an encyclopædia 'however beautiful is ephemeral', unless it can be maintained up to date by some means or other. The purpose of this Supplementary Volume of 974 pages is to bring the Encyclopedia up to date. As pointed out in the foreword, obsolescence is most uneven. Some of the articles in the earlier volumes needed to be brought up to date by alluding to minor improvements in production methods or by providing more up-to-date statistics, but in other articles changes of method may have been so great that considerable revision was indicated. In preparing the Supplementary Volume, the principle adopted has been to describe fully those bigger changes, rather than to make minor additions to the many different articles. Some articles have been added on subjects which were not treated in detail or not at all in the original volume; for example, fluidization and automation.

There are fifty-one articles in the Supplementary Volume, arranged alphabetically. Cross references are made to the original volumes as well as to this one. The index of 43 pages covers the Supplementary Volume alone, and should be consulted together with the very complete index to the original fifteen volumes which formed the greater part of Volume 15.

It is noticed that this new volume is called the First Supplement Volume, and it is well that the publishers seem to be allowing for the future and that further volumes may be expected which will maintain the current utility of the Encyclopedia. Many of the separate articles state at the outset the reasons which have led to their inclusion in the Volume and their relation to former articles in the Encyclopedia and some of the articles give at the end, in a few sentences, the main conclusions and expectation of further progress. This procedure is helpful to the user of this or subsequent supplementary volumes of the Encyclopedia.

The original purpose of Kirk and Othmer's Encyclopedia was to produce a "comprehensive treatment of the American Chemical Industry". The joint authors were successful. Raymond E. Kirk, the senior editor, died after a short illness early in 1957; he lived to see the completion of his great work. The Supplementary Volume opens with a tribute to his memory by his collaborator, Donald F. Othmer.

Glancing through the volume, the first article deals with "Acrolein" and its derivatives, in which the condensation products leading to new polymers are described. "Adhesives" provides the next subject, dealt with in a general way showing the advances made since the preparation of the article in the first volume, particularly in metal-bonding. An interesting article follows on "Algal Culture". Utilization efficiency in growing *Chlorella* is only between 2 to 8 per cent, because of the low light-saturation point. Yields of 20–40 tons an acre a year could be reasonably expected on the basis of the present technology, but there are difficulties attending most of the schemes which have been tried. The articles on "Computers", describing and listing their various types, give a great amount of assistance in the choice of suitable equipment for the study of problems in chemical engineering. "Cyanoethylation", in which the proprionitrile group is involved, forms the subject of the next article, which discusses the recent important development of cyanoethylated cotton, along with polyacrylonitrile fibres. There is considerable reference to "Detergents" in the Encyclopedia, and the new section on this subject brings information up to date. There is no reference in this article to the difficulty of effluent treatment caused by the use of detergents. "Emulsion paints" are referred to as a major development in the paint industry. The binder in water paints is glue or casein, which is made soluble in the water; in emulsion paints, it is insoluble and dispersed in very fine droplets.

"Industrial Enzymes", like papain, are used for chill-proofing of beer, for making meat more tender and for pharmaceutical purposes. 'Pectic' enzymes are used widely in the fruit juice industry. A table is given of industrial and food enzyme preparations on p. 309. "Epoxy resins", derived from epichlorohydrin, have found in recent years many applications as durable crosslinked polymers, used for protective coatings, finishes, metal-to-metal adhesives and structural materials.

Modern methods of "Extraction" as a chemical engineering unit operation are considered in a special article—an unusual example is cited, namely the extraction of fission products of spent nuclear reactor fuel by using molten silver, cerium or lanthanum as selected solvents. "Fluidisation" is one of the chief articles and it is a particularly useful addition to the Encyclopedia. On p. 399 is a diagram representing the results of a number of investigations on heat transfer between fluid beds and tube walls.

The supplementary article on "Hydrocarbon Oxidation" deals with vapour phase oxidation of the lower saturated aliphatic hydrocarbons and outlines, in not too dogmatic a manner, the theory of the chain reactions which can take place. In practice, formaldehyde, methanol, acetaldehyde and acetone are the main commercial products in the oxidation of propane and butane, which is carried out at 100–300 p.s.i.g., sometimes using oxygenated air. "Ion Exchange Resins" are becoming applied for many different purposes. The article refers to water treatment, to recovery of uranium from low-grade ores, to recovery of gold and other metals from cyanide leach, and to processing various pharmaceutical products.

The article on "Peracetic Acid" is excellent. Not many years back, peracetic acid was just a dangerous substance; now, though still unstable when pure, it has become (in solvents or formed *in situ*) an important oxidizing agent for epoxidation of natural oils and their derivatives, and a number of other uses. An article on "Photovoltaic Solar Converters" describes the advances made in photovoltaic cells for the direct conversion of the energy of light to electrical energy, using silicon or cadmium sulphide; other substances, such as gallium arsenide, indium phosphide or cadmium telluride, should be effective.

Polymerization of pure isoprene in the presence of a lithium metal catalyst produces a polymer with structure substantially identical with that of natural rubber. This and other developments in artificial rubber production are presented in the article on "Rubber". "Sorbic acid", a fungistatic agent for foods, has an article to itself, in which methods of production and other uses are described. "Steroids with Corticle Hormone Activity", describing the constitution and production of cortisone and derivatives, provides a valuable review and literature summary, including the cortexone derivative.

This Supplementary Volume contains articles of great current interest which illustrate the remarkable rate of progress of technology.

An encyclopædia is not only valuable for reference and for obtaining knowledge about some special subject, but, like a library, it is pleasant to browse within it, for browsing as well as study often leads to new ideas. This supplementary volume of "Kirk and Othmer" maintains the excellent standard of presentation of the main series of volumes and is an essential addition to the set. A. C. Egerton

EMULSIONS

Emulsions

Theory and Practice. By Paul Becher. (American Chemical Society Monograph Series, No. 135.) Pp. ix+382. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 100*s*.

One of the most complex of the systems dealt with in colloid science is that of the emulsions. This is in no small measure due to the fact that they are essentially metastable and in disequilibrium. Dr. Becher quite rightly introduces the subject by giving a brief review of the properties of interfaces and the characteristics of surface activity. In this section the author covers a lot of ground; the discussions on solubilization and on micelle structures are particularly welcome, although the treatment of Gibbs's fundamental equation and its experimental verification might have been dealt with in greater detail, especially in its applicability to micelle-forming electrolytes.

The general physical properties of emulsions are next described before attempting to inquire into the theoretical basis for the apparent stability of such systems as well as the cause of phase inversion. These chapters are excellent in that they emphasize the importance of the interfacial phase in acting as a barrier to the coalescence of liquid drops when brought in contact with one another. Not only must the electrostatic component of the repulsive forces which is approximately proportional to ζ^2, where ζ is the electrokinetic potential, as well as the London, or van der Waals, forces, be considered, but also there is increasing evidence that in the aqueous phase at least the water in close proximity to the interphase has become more ice-like under the influence of the potential gradient existing there, and that the breaking of this ice-like layer in the act of coalescence is a factor that cannot be left out in any computation.

The author rightly points out that the phenomenon of coalescence is an important initial step in both phase inversion and in creaming, where the emulsion separates into two phases, one rich and one poor, in the disperse phase, and the views of Cockbain and of Schulman are clearly presented.

The next two chapters are devoted to a classification of the different types of emulsifying agents and to the various techniques which have been developed for the preparation of emulsions.

The variety of surface-active agents employed for emulsion formation is now extremely extensive. In general, the chemical constitution of such amphipathic substances effects a nice balance between the polar and non-polar portions of the molecule which may be positively, negatively or zero charged. Some discussion on this balance would not have been out of place in this section; for example, a consideration of the ratio of the number of ethylene oxide groups to methylene groups required for a good aliphatic non-ionic detergent. There are two appendixes, one on testing and the other on commercial emulsifying agents.

This is a well-written book, concise in the American style, and the theoretical treatments, where developed, are integrated more closely in the corpus of the volume than is usual in such books. There are few obvious misprints. The format and printing are well up to the standard that we have come to expect of the American Chemical Society Monographs.

Eric K. Rideal

CHEMISTRY OF PLANTS

The Chemistry of Plants

By Prof. Erston V. Miller. Pp. vii+174. (New York: Reinhold Publishing Corporation; London: Chapman and Hall, Ltd., 1957.) 38*s*. net.

The principal function of a book on the chemistry of plants is to provide a source of information on the composition of plant tissues and the chemical properties of their major constituents. For the majority of readers, however, such a book would be made more interesting by some discussion of the metabolic relationships of these constituents. In his preface Prof. Miller makes it clear that he does not embrace this latter view and has specifically avoided encroaching on the domain of the plant physiologist.

In fact, the author has not been entirely successful in this and does offer a certain amount of biochemical information, but in quality and amount this is insufficient to redeem the failings of the book as a source of factual information. The author describes himself as "a mere compiler", but in this book he has rather been a collector of the compilations of others. All the tables, except one, are borrowed from other texts, and in most cases this transfer has reduced their value in that they were not specifically designed for their present context. This has the effect of making the presentation scrappy and the density of information variable and in many places very low. For example, there are given very few quantitative data on the composition of plant tissues and no information on the composition of plant proteins, though both types of data are readily available.

In view of this latter criticism, one might hope that the qualitative data be satisfactorily presented, but unfortunately, this is not the case, as its chemical content is particularly open to criticism. Many substances are mentioned without any indication of their structure being given, other substances of quite elementary importance, such as the unsaturated fatty acids, are inadequately described and some of the information given is quite inaccurate. Isocitric acid is not "the D-isomer of citric acid", hæmocyanin is not, so far as we know, closely related to chlorophyll, and phosphorylases are not to be confused with phosphorylating enzymes. These are just a small sample of the many errors which suggest that the author would be more at home in some other field than the chemical one. Finally, the price is rather high for a book of this size and the text would have to be very greatly improved to justify it.

G. Leaf

CELLULAR BIOLOGY

Les Facteurs de la Croissance Cellulaire

Activation et Inhibition. Publiés sous la direction de Prof. J. André Thomas. (Exposés Actuels de Biologie Cellulaire : 2è série, 1956.) Pp. xii+428+3 planches. (Paris : Masson et Cie., 1956.) 4,000 francs.

A GREAT many books and reviews on the biology of the cell have been produced in recent years, and since the War many new techniques have been applied to this field of research with startling success. Here is yet another review, and although many of the topics dealt with have been more widely surveyed in recent years, often by the same authors, this new collection of articles is nevertheless valuable. With ten authors involved in the production of nine chapters there is inevitably some unevenness in quality. On one hand, some authors have notably failed to include references to all the major work in their field, while on the other an outstanding contribution with a most comprehensive bibliography is that of Chouard and Thimann, who discuss "Les facteurs de la croissance cellulaire végétale".

The reviews included range from the synthesis of proteins through growth in animal and plant cells, growth and differentiation in embryos, the inhibition of mitotic activity, wounding and grafting, to a final review of cancerous growth. Brachet's paper, entitled "Les facteurs d'activation et d'inhibition de la synthèse des protéines", forms an excellent introduction to this subject, and could be read with great advantage by final-year honours students. This can also be said of the chapter by Chouard and Thimann mentioned above. The other contributions are less likely to have a general appeal. In particular, it is remarkable that in a book of this nature there should be no chapter dealing with the great advances which have recently been made in our understanding of the normal physiology of cell division. Instead there are two chapters on "Les facteurs de la mito-inhibition" (Deysson and Dustin), and one on "Les facteurs de la cytonarcose" (Gavaudan), and, although all are interesting, they deal primarily with the toxicology and pharmacology of mitosis.

The final two chapters, on wounding and grafting (May) and on cancer (Oberling), are both interesting, but they are too brief to be of any great value. Indeed the whole book is of an introductory nature, and, apart from the serious omission mentioned above and the pharmacological over-emphasis, its greatest value will be to provide an outsider with some knowledge of modern research work on cellular biology.

W. S. Bullough

A FARMER'S GUIDE TO ANIMAL DISEASES

Veterinary Guide for Farmers

By G. W. Stamm. Edited by Dallas S. Burch. Third edition. Pp. 384. (Chicago, Ill.: Windsor Press, 1957.) 3.95 dollars.

ANIMAL diseases are of great importance to all farmers, for upon their incidence can depend the success or failure of the enterprise. A reduction in the losses caused by animal diseases would greatly benefit the farming community, and the aim of this book is to assist farmers to accomplish this by providing them with information on the diseases which can affect their stock.

The book has been written clearly and concisely, and much technical veterinary knowledge has been simplified and expressed in a manner which can be understood by practical farmers. The book is well produced and excellent photographs and informative diagrams make the author's meaning clear. As the book was written for American farmers it deals with poisonous plants, parasites and diseases which are unknown in the British Isles, and advises the use of drugs, such as antibiotics, which cannot be purchased by farmers in these islands. Also, in dealing with some diseases, no mention is made of prophylactic preparations which British farmers are using extensively. However, providing the reader has the knowledge to appreciate which sections are applicable to his particular conditions, he can obtain information about the diseases which can affect his stock, and the measures which can be adopted to prevent their spread.

This book, however, aims at taking the farmer further than the elementary principles of first aid and the important aspects of disease prevention, and provides information which will enable him to diagnose and treat disease. Skill in diagnosis is an art which can only be acquired by long experience, and text-book knowledge can, in certain cases, increase losses by leading to an inaccurate diagnosis and faulty treatment. An additional point is that veterinary surgeons are relying increasingly on diagnostic aids such as bacterial examinations and biochemical analyses which are not available to farmers. Other sections of the book dealing, for example, with the diagnosis of pregnancy, do not stress the time and practice needed to acquire skill in the technique.

The book is an excellent one of its kind and contains much valuable information, and, in the foreword, the author warns his readers not to take chances with sick animals, but to seek veterinary advice in cases of uncertainty; but it does tend to encourage farmers to perform for themselves services which would be more efficiently provided by the veterinary profession.

J. O. L. King

D'ARCY WENTWORTH THOMPSON

D'Arcy Wentworth Thompson

The Scholar-Naturalist, 1860–1948. By Ruth D'Arcy Thompson. Pp. xi+244+8 plates. (London: Oxford University Press, 1958.) 25*s*. net.

All of us who knew D'Arcy Thompson personally and the many who made his acquaintance through the pages of "Growth and Form" have reason for gratitude to his eldest daughter for this finely written biography. It brings vividly into memory that majestic figure and ponderous, admirably phrased utterance. There has been, as all must agree, no one like him in the world of zoology, or possibly in that of any other science, in our time.

He outlived his contemporaries, and most of us who knew him first met him as the author of "Growth and Form" and professor of natural history at St. Andrews, already on the high plateau of the last half of a professorial career that was to extend over sixty-four years. Of how many people would one remember the very first words heard from them? But there is vivid recollection of the opening phrase in an address he delivered before the Royal Physical Society of Edinburgh some thirty-five years ago. Speaking of Johannes Schmidt and his then recent discovery of the breeding places of the eel, he began, "Aristotle"—a long pause and then again—"Aristotle, who knew a little about everything but not everything about anything . . ." and we were launched on an account of modern achievement against a background of classical knowledge.

But, as we learn with so much interest from this 'life', the journey up to the summit of achievement and recognition had been full of disappointments. The chair at Dundee, obtained at the age of twenty-four, was after all a poor alternative to the fellowship at Trinity, Cambridge, that he had hoped for, and there were repeated failures to obtain other chairs or museum directorships. No comparative anatomist, he was out of step with his contemporaries and had he died before the publication of "Growth and Form" (when he was already fifty-seven) he would have had scant attention in any subsequent history of zoology.

His achievements to that date lay primarily in the fields of classical scholarship and of fisheries statistics. Even the two visits to the North Pacific as the United Kingdom representative on the Bering Sea Commission in 1896 and 1897, description of which forms perhaps the most interesting chapter in this book, brought him governmental rather than scientific recognition.

All changed in 1917 after the publication of "Growth and Form", and fame was assured. In this remarkable book his wide knowledge, his mathematical ability and, above all, the wide philosophical outlook which he shared with the Greeks whom he studied and so much admired, find full scope. Supremely well written, it has had a major influence on the direction of biological thought and research, the latter the more surprising because its author was not himself an experimentalist. In a postscript to this biography, Prof. P. B. Medawar contributes a critical essay of high distinction on "Growth and Form".

Perhaps the only criticism concerns the illustrations which could, one feels, have been better chosen. But taken all in all, this is a biography not unworthy of its subject and one that should be widely read and the more treasured as time passes, and with it the memory slowly fades of a great zoologist and a most remarkable personality.

C. M. Yonge

ALEXANDRE COLLIN—A PIONEER IN SOIL MECHANICS

Landslides in Clays

By Alexandre Collin, 1846. Translated by W. R. Schriever, with the assistance of J. P. Carrière, R. F. Legget, and D. H. MacDonald; with a Memoir on Alexandre Collin by A. W. Skempton. Pp. xxxvi+160+21 plates. (Toronto: University of Toronto Press; London: Oxford University Press, 1956.) 52*s*. net.

A reference which appears in all the standard soil mechanics text-books is to Alexandre Collin's "Recherches Expérimentales sur les Glissements Spontanés des Terrains Argileux" (Carilian-Goeury, Paris, 1846). It is a work that has been more quoted than read, and the translation by W. R. Schriever, entitled "Landslides in Clay", is most welcome, for the full text of this work, which is of great historic interest, can now be read by a wide public.

Historically, the work is important to civil engineers, for Collin was much ahead of his time; indeed, nothing approaching the quality of his work was done in soil mechanics for another fifty years. He used the inductive approach, carefully measuring up landslides when they occurred and basing his theories on the considerable amount of field evidence which he had collected. These data are still of value. Others of his contemporaries were deriving mathematical formulæ which bore little relation to the soil to which they were applied.

The analysis of slope stability as carried out to-day is fundamentally that outlined by Collin. He did not, however, attach great importance to this analysis and it is relegated to an appendix in the book.

His description of how he measured the mechanical properties of clay is also very interesting. He demonstrated how clay swells and shrinks with a change in water content, and showed how the shearing resistance also changes. This he measured by applying loads to specimens 4 cm. × 4 cm. in section, producing a double shear failure.

It is difficult to understand why this research was not followed up, and in a memoir on Collin, published with the translation, Prof. A. W. Skempton provides some reasons for it. The memoir is helpful, for it evaluates Collin's work not only in its contemporary setting but also shows where it lies in terms of our present-day knowledge.

Translating such a work cannot have been easy, but the English is extremely readable while yet retaining the feel of a work written in French more than one hundred years ago. To read it is a delightful and instructive recreation.

K. L. Nash

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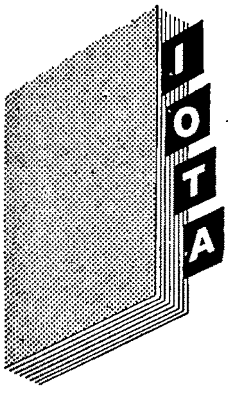

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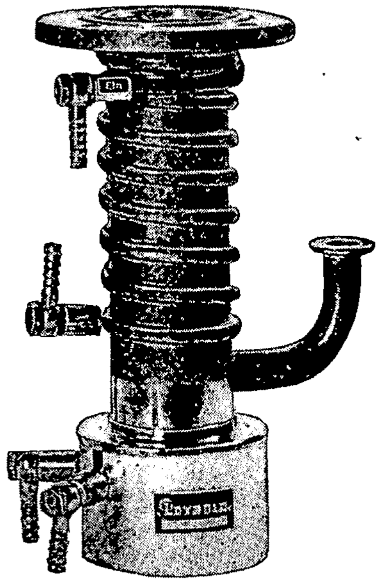

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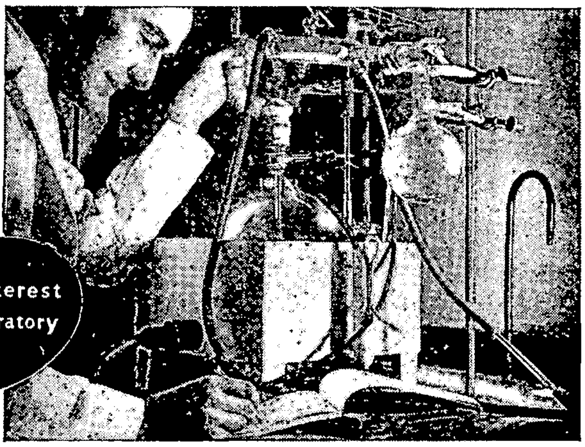

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Health Yearbook, 1956

Compiled by Prof. Oliver E. Byrd. Pp. vi+278. (Stanford, California: Stanford University Press; London: Oxford University Press, 1957.) 40*s*. net.

Since 1943 the University of Stanford has published an annual Health Yearbook. Over the past few years these have been compiled by Prof. O. E. Byrd, professor of health education, who has brought to his task both diligence and zeal removed from the ordinary. For the 1956 Yearbook Byrd read some 2,000 articles culled from more than 300 health journals. From these he has chosen 254 which constitute a representative sample of the published health literature for 1956. The essence of each article has been patiently distilled and then set down by Byrd in language which would commend it to health educationists, both lay and professional.

The topics discussed include problems of rehabilitation, physical fitness, mental health, heredity and eugenics, infection and immunity, chronic and degenerative disorders, habit-forming substances, dental health, and safety, as well as the facilities available through health authorities, occupational and community health services. There is also a chapter giving accounts of developments in the international health education field, particular attention being paid to Western Germany, South America, Puerto Rico, India, the Soviet Union and Central Africa.

Although most of the book will be of most value to American readers, the editor has chosen his articles so wisely that a large part of it will be of interest and value to health educationists everywhere. Even in matters concerned with the United States, Prof. Byrd has risen above the parochial to set out general principles of health education rather than its local application. Inevitably there is over-lapping and some of the topics appear to hold most interest for the original authors. Yet it is surprising in a compilation of this kind how much of general interest the editor has brought together in a work which will be of value to all those looking for a résumé of important developments in health education during recent years.

K. M. Hawkins

Commonwealth Universities Yearbook, 1958

Pp. xxvii+1337. (London: Association of Universities of the British Commonwealth, 1958.) 84*s*.

The expansion in both size and numbers of the universities of the United Kingdom and of the British Commonwealth has led over the years to a corresponding growth in the Universities Yearbook, which had evolved into a squat bulky volume; the last edition contained more than 2,000 pages. Now the 1958 edition of this valuable work of reference has been issued in a new and much improved format comprising some 1,300 pages of larger size, set in a clearer type from which the subject headings stand out boldly. It is bound between dark blue, dirt-resistant covers. The contents of the book have also been completely rearranged. Hitherto, the United Kingdom has always come first, but now the Commonwealth countries are taken in alphabetical order, headed by Australia, Canada, Ceylon and Ghana. The United Kingdom comes near the end after Uganda, and followed only by the West Indies and an appendix on certain universities—in the Republic of Ireland and the Sudan—having close historical ties with the Commonwealth.

Another distinctive and particularly valuable feature of the new edition is a series of authoritative essays by distinguished academic writers, introducing the sections dealing with Australia, Canada, India, South Africa and the United Kingdom, and describing the system of education in each of these countries leading up to the several university institutions. These essays deal with the history, constitution, relations with the government, and finance of the universities in the countries to which they relate, with sections on pre-university education, conditions of admission and the courses available. Together they form an exceptionally valuable survey of the diverse educational and university systems obtaining in various parts of the Commonwealth.

The directories of the individual universities retain most of the features which have characterized previous editions. They give details of the staffs, activities, regulations and histories of each up to May or June 1957 and in some cases to a rather later date. There is also an appendix giving a statistical analysis of the 10,433 students from overseas enrolled at universities in Great Britain for the academic year 1956–57, and an index of nearly 40,000 names, including all university teachers and administrative officers mentioned in the text.

The Association of Universities of the British Commonwealth is to be congratulated on the changes, which still further enhance the value of this distinguished compendium of basic information indispensable to educationists and to all who are concerned with academic matters.

Bergey's Manual of Determinative Bacteriology

By Prof. Robert S. Breed, Prof. E. G. D. Murray and Nathan R. Smith. Seventh edition. Pp. xviii+1095. (London: Baillière, Tindall and Cox, Ltd., 1957.) 120*s*.

The Bergey Manual is unique among books on bacteriology and a new edition can only be compared with earlier ones. The seventh has been greatly improved by the deletion of material, chiefly of interest to the nomenclaturist, which is to appear in a companion volume, the "Index Bergeyana".

The Manual has a twofold task: to give details of the cultural characters of well-defined species, and to indicate how these species may be collected together into genera and higher ranks. Success in the first depends on the individual authors (there are about a hundred of them) responsible for the particular sections. The new edition is better than the last because many more specialists are included among these authors, and the editorial board has concentrated more on general policy than on writing individual sections. Some of the larger sections, for example the family Enterobacteriaceae, would have been better co-ordinated if they had been written by a group of workers or by the appropriate international taxonomic subcommittee.

As a guide to taxonomic thought the Manual has generally been in advance of similar thought on the eastern side of the Atlantic. In the new edition the thought is still there but it is conventional, and does not seem to be aware that many bacteriologists now question the applicability of a hierarchical system to the classification of bacteria. There is an implicit acceptance of the species concept, and the taxonomic precepts put forward are not likely to be accepted by those whose ideas and thoughts go beyond the immediate identification of the organism. S. T. Cowan

FURTHER STUDIES ON THE PROCESS OF SONG LEARNING IN THE CHAFFINCH (*FRINGILLA COELEBS GENGLERI*)

By Dr. W. H. THORPE, F.R.S.

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THE songs and other vocalizations of birds are of theoretical interest to both zoologists and psychologists. This is so because, first, they act as social communication systems and as a means of expression—in other words, as a language. Secondly, they provide specific recognition marks which suggest important problems in ecology and evolution. Thirdly, they pose problems concerning the inheritance and genetical control of extremely elaborate behaviour patterns. Finally, the vocalizations of birds can be regarded as offering particularly crucial problems concerning the acquisition of complex behaviour patterns as a result of individual learning.

In an article in *Nature* four years ago[1], it was shown that the normal song of the chaffinch (*Fringilla coelebs*) is an elaborate integration of inborn and learned components, the former constituting the basis for the latter. The present report summarizes very briefly progress which has been made since then. The full account of all the experiments will appear shortly[2].

A good example of a normal song of *F. c. gengleri* is given in Fig. 1. The inborn component of the chaffinch song can be revealed by hand-rearing the young birds from the early nestling life either in acoustic isolation or at least out of contact with all chaffinch song. Six birds thus individually isolated produced songs of an extremely simple type (Figs. 2–4) consisting of a song burst of approximately the correct length (2–2·5 sec.) made up of about the right number of notes. The pitch, or fundamental frequency, of these notes was somewhat lower than normal, and the songs produced by these isolates lacked the division into the three phrases so characteristic of the normal chaffinch song. Moreover, the final flourish and all the other fine details by which the chaffinch song is normally recognized as such were also absent. Of all the hundreds of wild and aviary-kept birds which have passed through our hands during the course of these experiments, none has produced songs of such extreme simplicity as these six birds, although such undeveloped songs are known to occur in the wild at times.

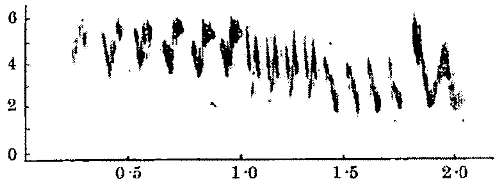

Fig. 1. 'Normal' song of British chaffinch (*Fringilla coelebs gengleri*) *BW/P*, May 9, 1952. Vertical scale: frequency in kc./s. Horizontal scale: time in sec. (Similarly in Figs. 2-11)

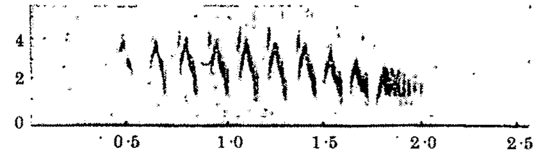

Fig. 2

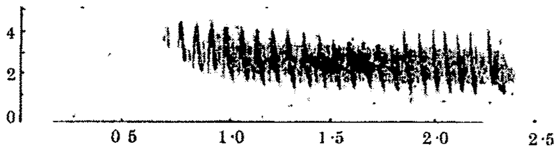

Fig. 3

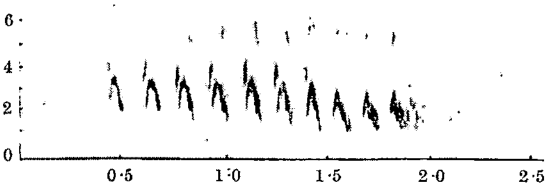

Fig. 4

Figs. 2–4. Song of three hand-reared auditory isolates. *GW*, June 24, 1954; *B/BkY*, May 25, 1957; and *BkW/W*, June 24, 1955

In contrast to the simple, restricted song produced by the isolated birds, we find that if, after babyhood, two or more such birds are put together in a room but still without the opportunity of hearing experienced chaffinches, they will develop more complex songs. It seems that the attempt to sing in company produces mutual stimulation which encourages the development of complexity. The members of each group of hand-reared birds thus kept together will, by mutual stimulation, build up a distinctive community pattern. The birds conform so closely to this pattern that it is sometimes barely possible to distinguish the songs one from another even by electronic analysis. The song of such birds may be quite as complex as that of a normal wild chaffinch, but its complexity tends to be of a different kind and a song thus produced may bear little resemblance to the characteristic utterances of the species. From further experiment it is clear that in the wild, young chaffinches learn some features of the song from their male parents or from other adults during the first few weeks of life. But most of the finer details of the song are learned by the young bird when, in its first breeding season, it first comes to sing in competition with neighbouring territory-holders. There is little doubt that this is the way in which local song dialects are built up and perpetuated. In addition to this true song, the chaffinch, like many other species, has what has been called a sub-song, which is a much quieter and less aggressive affair than is the full song. It is, however, not merely a song of low intensity: it is of an entirely different pattern from the true song and may be described as a long succession of chirps and rattles[2-4]. It seems to have no communicatory function and is most frequently heard in the early spring, when it is produced, so far as we know, much more by first-year birds than by older ones—the latter seeming to come into full song with much less of this preliminary sub-song. There seems little doubt, however, that the sub-song provides in some degree the raw material out of which, by practice and by the elimination of unwanted extremes of frequency, the full song is 'crystallized'. The chaffinch has, of course, like other species, a number of call notes which are in the main signals for co-ordinating the behaviour of the flock, mate and family; some of these may be used as components of both sub-song and full song. It is interesting that call notes are much more in evidence as components of the songs of isolated birds than they are in the songs of normal ones. This is presumably because the isolated birds have had a greatly restricted auditory experience to draw upon as compared with normal wild individuals.

Chaffinches are not imitative birds, in that they do not normally copy anything but sounds of chaffinch origin. Once a chaffinch has heard a chaffinch song as a young bird in the wild, it appears to have learned enough about it to refuse to copy any sound pattern which departs far from the normal; that is, it will learn only the finer individual variations of the song of other chaffinches. So, in the wild, chaffinches practically never, in their full songs, imitate anything but other chaffinches. Hand-reared, isolated birds will learn songs of far greater abnormality, however, provided always that the tonal quality is not too different from that of a chaffinch song. Voices as 'abnormal' as that of a domesticated canary (*Serinus c. canarius*) may be learned by hand-reared birds[3], and very occasionally by wild birds; but when this happens the alien notes are kept as components of the non-communicative sub-song only; the full song is not contaminated with them.

If one catches wild chaffinches in their first autumn and keeps them until the following spring with other chaffinches the song of which is already fixed, one gets clear evidence that the young birds have modelled their songs, in some respects at least, on those of their associates, which have probably come into song first as the spring season comes on, and which they thus hear before they themselves have got very far along the path of song production. Similarly if, instead of exposing such wild-caught first-year birds to the songs of other chaffinches, one plays such songs to them by means of the repeating tape machine which we call a 'song tutor', a clear positive effect is manifest. An experiment carried out in 1954–55 with four wild-caught birds given such tuition in the winter (January 6–20) and with three birds similarly treated in February–March showed clearly the effect of the 'song tutor', there being correct articulation of the phrases and a good approximation in pitch and quality, although there were abnormalities in length and emphasis. If, however, under these conditions one exposes the young birds to highly abnormal songs, no result is obtained. Thus in experiments in 1955–56 such birds were given tuition with a reversed chaffinch song during March. The fact that no definite effect was obtained suggested that enough of the song had already been learned in the autumn for the reversed song to be ineffective even with visually isolated birds. In 1956–57 a similar experiment was done using six wild-caught autumn males and exposing them, in this case not to a reversed song, which was thought to be perhaps too abnormal, but instead to three different 're-articulated' songs (these are songs in which the position of the three phrases has been interchanged). In this experiment the birds were isolated in a soundproof room. Two birds had exposures in September and October, repeated in January, two had exposures in mid- to late-October and late January and early February, and two were similarly exposed in November and February. On the whole, this experiment also had little effect, confirming the tests with the reversed song and suggesting even more strongly that the natural training which the bird has already received by the time it has reached its first winter moult has equally been sufficient to prevent it from learning afterwards the rather large abnormalities characteristic of these re-articulated songs.

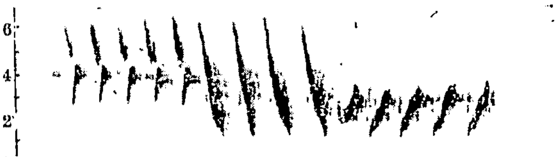

Fig. 5

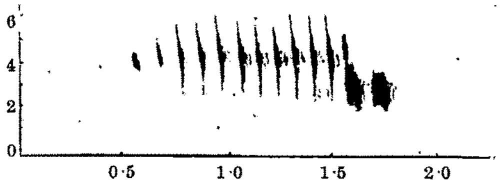

Fig. 6

Figs. 5 and 6. Two songs of a hand-reared auditory isolate after having been exposed to normal song on the 'song tutor' for 10 days only during November of its first year. *GY/BW*, April 24, 1956

When we come to similar experiments with hand-reared birds, very different results are obtained. It was found that a hand-reared visual isolate can be taught features of a normal song from the tape by being exposed to it during November only of its first winter for a period of 10 days. Figs. 5 and 6 give the two songs developed in 1956 by such a bird treated in 1955. The first song shows clearly the influence of the 'tutor', in that it has three phrases otherwise unknown in a hand-reared isolate, having a clear stepwise descent but no end phrase. The second song is of the isolate type plus two end-notes. These experiments thus produce evidence that tutoring, even for a short period in November, can effect the same kind of result as the normal song experience of a wild bird in the field during the autumn. Similar positive results were obtained in similar experiments with re-articulated songs carried out in 1956–57 and 1957–58. Figs. 7 and 8 show such a re-articulated model and its effect on the song of a hand-reared isolate. Hand-reared birds show similar differences from the wild-caught ones, in that if given a reversed song a considerable amount of copying is achieved. Similar experiments with other birds provide further evidence for a previous conclusion that although a hand-reared isolate is incapable by itself of producing anything approximating to a normal ending, yet if once it hears a normal end-flourish on the 'song tutor' (even though in the re-articulated song on the tape it occurs at the beginning or in the middle of the song) it will recognize it as appropriate for an ending and will attempt to place it properly in its own song.

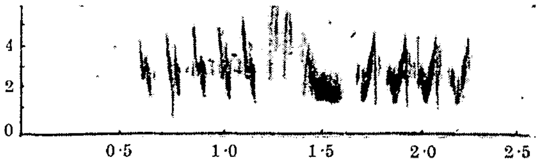

Fig. 7

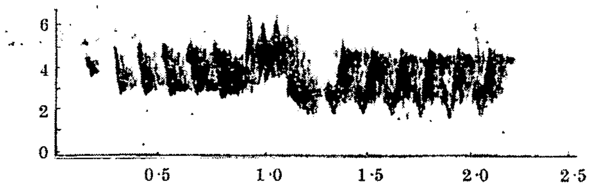

Fig. 8

Fig. 7. Re-articulated model with 'end in middle'

Fig. 8. Song of hand-reared auditory isolate *B/BkP* after having been exposed to this model for 12 days January–February and 12 days February–March. March 25, 1958

In experiments in 1954–55 an attempt was made to indoctrinate hand-reared isolate chaffinches with the song of the tree pipit (*Anthus trivialis*) (Fig. 9), this being chosen because the spectrograph reveals that the tonal quality of the notes is similar to that of the chaffinch. The first experiment gave a doubtful result; but a repeat in 1956 resulted (Fig. 10) in the achievement of a remarkably good copy by such a chaffinch of the song of a tree pipit, resulting in a chaffinch song entirely unlike any other produced in my experience by a wild or hand-reared bird. It is of interest to note that the rather long song of the model has been condensed to conform to the standard length of chaffinch song by condensing the middle phrase of the tree pipit song to two notes instead of four. This song became still further 'tightened up' and shortened by the beginning of May (Fig. 11).

The reason why chaffinches do not imitate and acquire songs from other species in the wild now seems fairly evident. There is little doubt that they restrict their imitativeness to the right models as a result of being responsive only to notes of approximately the right tonal quality. It is interesting that the imitation of the tree pipit song just referred to is the best copy of an alien song so far obtained. Here the tonal quality of the model was right, although the song itself was much too long and the phrasing of the notes of the model abnormal from a chaffinch point of view.

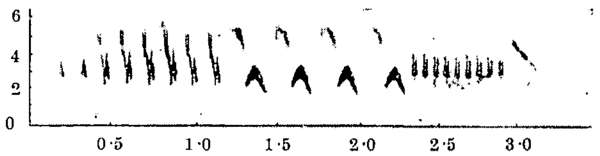

Fig. 9

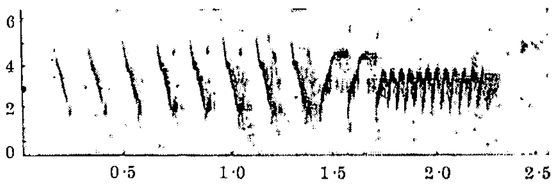

Fig. 10

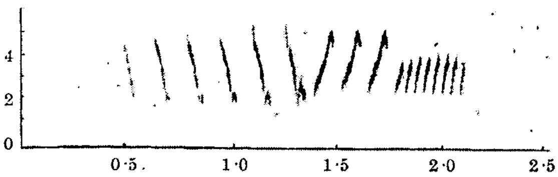

Fig. 11

Fig. 9. Song of Continental tree pipit (*Anthus trivialis*) used for tutoring

Fig. 10. 'Copy' of tree pipit song produced by chaffinch *R/R* after tuition on 'song tutor', April 21, 1956

Fig. 11. 'Improved' tree pipit copy. *R/R*, May 3, 1956

To summarize this work with the 'song tutor', it can be said that in eleven experiments carried out over the years 1955–57 and involving thirty-four wild autumn-caught first-year males, the only positive effect obtained (in the sense of a significant similarity between model and mimic) occurred in two experiments (seven birds) only, and in these two the model was a normal chaffinch song. Of the remaining ones (nine experiments, twenty-seven birds) the models were always abnormal—the songs being artificial, re-articulated or reversed—and the results were always negative. The contrast when hand-reared isolated birds are used is striking. Thus during 1954–59, thirteen experiments involving sixteen hand-reared birds were carried out using similar song models. Of these, ten experiments (eleven birds) were positive in the sense of yielding a significant effect. The remaining three experiments (five birds) gave a negative result.

The counter-singing that occurs between birds in adjacent territories is an important factor in stimulating and restricting the imitative abilities of chaffinches. When a chaffinch has acquired more than one song-type, each song-outburst consists of a sequence of one song-type followed by a sequence of another. When songs are played back to a chaffinch, we find that those songs which it uses most frequently itself are the most effective in evoking song[5]. A chaffinch in the wild will thus tend to reply to a neighbour with that song of its own repertoire which most nearly resembles the song of its rival.

It is suggested that, with the more 'imitative' finches such as the bullfinch (*Pyrrhula pyrrhula*), hawfinch (*Coccothraustes coccothraustes*) and to some extent greenfinch (*Chloris chloris*), the song, while functional in co-ordinating the breeding cycle and behaviour of the mated pair, is of less importance as a territorial proclamation. Thus in some respects it resembles the sub-song rather than the full song of the chaffinch; similarly, contamination with alien notes can be tolerated to an extent which might be very disadvantageous in a strongly territorial song that must maintain its character as a reliable specific recognition mark. A preliminary study of a number of species of buntings shows that many of the species, for example, reed and corn buntings (*Emberiza schoeniclus* and *E. calandra*), have songs which are highly stereotyped and completely innate. The song of the yellow bunting (*E. citrinella*) appears to consist of an integration of innate and learned components much as in the chaffinch. The buntings as a whole appear to have strongly territorial songs corresponding in function to that of the chaffinch.

Apart from a very few and partial exceptions, chaffinches can learn song patterns only during the first thirteen months of life, and towards the end of this time there is a peak period of learning activity of a few weeks during which a young chaffinch may learn, as a result of singing in a territory, the fine details of as many as six different songs. This special period of high learning ability is brought to an abrupt close by internal factors. It matters not whether a chaffinch has learned one or six songs by the time it is thirteen months old, it can afterwards learn no more, and so it remains with its one song or its six for the rest of its life. This restriction of learning ability to a particular type of object and to a sharply defined sensitive period recalls the phenomenon of imprinting.

The inborn recognition and performance of its specific song by the chaffinch involves (*a*) duration of approximately 2½ sec., (*b*) interval between songs of between 10 and 20 sec., (*c*) tonal quality (though this last may have been learned by the experience of the bird of the qualities of its own voice). The readiness with which the bird learns to divide its song into three sections and learns to attach a simple flourish at the end as an appropriate termination shows that there must be an imperfectly inherited tendency to respond to, and perform, the features of the normal song as soon as the singer is stimulated by hearing another bird. Such an inherited tendency would explain the basic similarity of the songs of the species throughout its range.

[1] Thorpe, W. H., *Nature*, **173**, 465 (1954).
[2] Thorpe, W. H., *Ibis*, **100**, Pt. 3 (1958).
[3] Thorpe, W. H., *Ibis*, **97**, 247 (1955).
[4] Thorpe, W. H., and Pilcher, P. M., *British Birds*, **51** (1958).
[5] Hinde, R. A., *Anim. Beh.*, **6** (1958).

THE ELECTRON TEMPERATURE IN SCEPTRE III

By Dr. S. KAUFMAN and R. V. WILLIAMS
Research Laboratory, Associated Electrical Industries, Limited, Aldermaston

IN high-current discharges of the type observed in ZETA and SCEPTRE[1] thermodynamic equilibrium does not exist, and the ions and electrons may be at different temperatures. The Doppler broadening of spectral lines is evidence of large ion velocities, although it has yet to be shown conclusively that the motion is associated with a real ion temperature. On the other hand, no results have yet been published on the electron temperature T_e.

In general, it should be possible to determine T_e from a study of spectral excitation by electron impact, and qualitative variations in electron temperature for different conditions of the SCEPTRE discharge were at first observed from the relative strengths of spectral emission in different stages of ionization (for example, O V/O IV)[2]. However, an absolute determination of T_e is generally difficult because of the multiplicity of processes which can populate an atomic level. It is proposed that this problem can be simplified if a suitable atom of the He I iso-electronic sequence is chosen. From a preliminary measurement of the absolute intensity of a C V spectral line, T_e has been estimated to be $2 \cdot 5 \times 10^6$ deg. K. to within a factor 2, on making the basic assumption that run-away electrons do not contribute appreciably to the excitation.

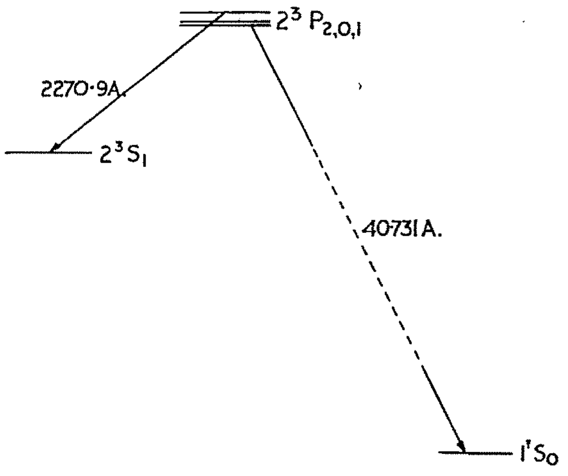

Fig. 1. Partial Grotrian diagram of the He I iso-electronic sequence. Wave-lengths and relative positions of the triplet lines refer to C V

Atoms of the He I iso-electronic sequence are particularly stable. For example, while the ionization potential of C IV is only 64·5 eV., the lowest excitation potential (E_{12}) of C V is 304 eV., excluding the neighbouring 2^3S metastable level (Fig. 1). Thus, cumulative processes from previous stages of ionization are comparatively unimportant and it is assumed that the C V spectrum will not be excited appreciably until all the carbon atoms are in the ground-level $1\,^1S$ of C V (cf. the conditions in Wolf-Rayet stars[3]). We also suppose that the 2^3P_2 level of C V is filled entirely by electronic excitation from this level (population N_1). The competing processes which populate the 2^3P_2 level (cascade from upper levels and electronic excitation from the 2^3S level) and de-populating processes other than radiation (namely, electronic excitation and super-elastic collisions from the 2^3P_2 level) are neglected; their effect on the measured temperature is considered below. The transition $1\,^1S_0$–2^3P_2 is forbidden for dipole radiation. In the steady state which is attained after about 10^{-7} sec., the rates of electronic excitation of the 2^3P_2 level and radiation from this level by the line (2^3S–2^3P_2) at 2270·9 A.[4] will therefore be equal. Hence, the specific intensity I of this line is

$$I = 2\left(\frac{2kT_e}{\pi m}\right)^{\frac{1}{2}} N_1 n Q_{12} h\nu \left(1 + \frac{E_{12}}{kT_e}\right) \exp\left(-\frac{E_{12}}{kT_e}\right)$$

where k is Boltzmann's constant, m the electron mass, n the electron concentration, h Planck's constant and ν the frequency of the spectral line. The cross-section Q_{12} for electron impact from the 1^1S to the 2^3P_2 level is finite at the threshold energy and, for simplicity, is regarded as invariant with energy above threshold. Measurement of the absolute intensity of this C V line therefore permits an evaluation of T_e, providing the other parameters are known.

The line at 2270·9 A. was first identified on several spectrograms but was faint and broad; the other members of the triplet were too weak for exact identification. To demonstrate this method of estimating T_e, a preliminary experiment was conducted under discharge conditions where the excitation of the O V line (2781 A.) was intense, namely, deuterium at a pressure of 1·4 millitorr, the condenser bank charged to 25 kV., turns ratio 16 : 1, initial toroidal magnetic field of 500 oersteds and peak gas current $1 \cdot 2 \times 10^5$ amp. Methane at a partial pressure of 3×10^{-5} torr was added to the deuterium to strengthen the C V emission and provide an estimate of N_1. The temporal and spatial intensity distributions of the line at 2270·9 A. were obtained with a combination of a monochromator and a photomultiplier. The intensity I of this line at peak excitation averaged over the central region of the torus was measured to be 4×10^2 erg. sec.$^{-1}$ cm.$^{-3}$. Peak excitation occurred at approximately peak current, which was unchanged by the introduction of the methane. From the above relation and taking the value of Q_{12} at threshold to be $1 \cdot 8 \times 10^{-17}$ cm.^{2} $(0 \cdot 2 \pi a_0{}^2)$, T_e was found to be $2 \cdot 5 \times 10^5$ deg. K.

It is fortunate that at about this temperature the exponential factor in the above relation is extremely sensitive to the smallest change in T_e. Therefore, only the order of magnitude of $N_1 n Q_{12}$ need be known and considerable latitude can be permitted for the magnitude of competing processes. In the estimation of N_1 we are justified in assuming that most of the carbon atoms are in the C V ground-level, for the excitation of the O IV line at 3063 A. was a minimum at the torus axis. If instead of the above excitation mechanism it is assumed that the dominant excitation of the 2^3P_2 level is from the 2^3S level, the electron temperature can still be calculated because the populations of the 2^3S and ground-levels are governed approximately by Boltzmann's distribution law. Even if Q_{m2}, the cross-section for this process is taken as large as 100 Q_{12}, T_e is only altered to $2 \cdot 0 \times 10^5$ deg. K. Super-elastic collisions from the 2^3P_2 level are relatively unimportant for the assumed value of Q_{12}. If this process were very much greater so that it predominated over radiation, the populations of the 2^3P_2 and ground-levels would also be determined by Boltzmann's distribution law: the calculated temperature would again be $2 \cdot 0 \times 10^5$ deg. K. The principal cascade effect to the 2^3P_2 level, namely, from the 3^3D term, is scarcely likely to alter the population of the 2^3P_2 level radically, for it is situated 50 eV. above this level. This large energy jump also reduces the compensating process of electronic excitation from the 2^3P_2 level. If the estimation of the coefficient of the exponential in the equation is considered to be in error by a liberal factor, namely, either 10^{-3} or 10^3, a range of $(1 \cdot 7–5 \cdot 2) \times 10^5$ deg. K. would be the uncertainty in T_e. For higher values of T_e, it will be important to know the magnitudes of Q_{12}, Q_{m2}, N_1 and n more exactly. Further theoretical and experimental work is in progress and it is hoped to publish a fuller account at a later date.

A value of $2 \cdot 5 \times 10^5$ deg. K. for T_e is consistent with qualitative observations of the plasma's electrical conductivity and O V emission. However, the need to explain the large Doppler widths which are observed is even more compelling than hitherto. Spitzer's suggestion[5] as extended by Gabor[6] that co-operative phenomena between the electrons and ions are responsible for the large ion velocities, need not be called into play.

We acknowledge our indebtedness to Dr. M. J. Seaton (University College, London) for having suggested to us the possible order of magnitude of Q_{12}, and to Prof. B. Edlén (University of Lund) for his assistance in the identification of the C V triplet. We are also grateful to Mr. T. P. Hughes for photographing the spectra, to Dr. A. A. Ware for his interest and comments on the manuscript, and to other colleagues of the Thermonuclear Section for their active help in running SCEPTRE III. We also acknowledge helpful discussions with our colleagues at the Atomic Energy Research Establishment, Harwell.

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RUDJER BOŠKOVIĆ INSTITUTE, ZAGREB

By PROF. IVAN SUPEK

President of the Council of the Institute

THE decision to found the Rudjer Bošković Institute was taken by the Yugoslav Federal Government in May 1950. At this time the building of the Boris Kidrič Institute, Vinča—the first institute for nuclear sciences in Yugoslavia—was almost complete, and that of the Jožef Stefan Institute in Ljubljana had just begun.

Although the emphasis is on nuclear physics, the Council of the Rudjer Bošković Institute intends to include activities in the fields of chemistry and biology. For this reason, laboratories for physical chemistry and biochemistry were built in 1952, and two years later two fairly large buildings, originally barracks, were adapted as biological laboratories.

The newly formed Council of the Institute wished to establish a firm basis for fundamental research in nuclear energy. The main problem was the need for scientific personnel on one hand and an insufficiently developed tradition of scientific training in the universities on the other. A large number of graduates, therefore, were sent abroad to continue their postgraduate studies. Most of them went to England, where they always found a ready welcome. For example, four of our students took their doctor's degree in experimental physics at the University of Birmingham.

Although three institutes for nuclear research work were under construction at the same time, the allocation of work among them was made at the very start, so that since then each has functioned as part of a larger organism.

As the Institutes in Vinča and in Ljubljana were chiefly interested in reactor physics, the Council of the Rudjer Bošković Institute decided at the end of

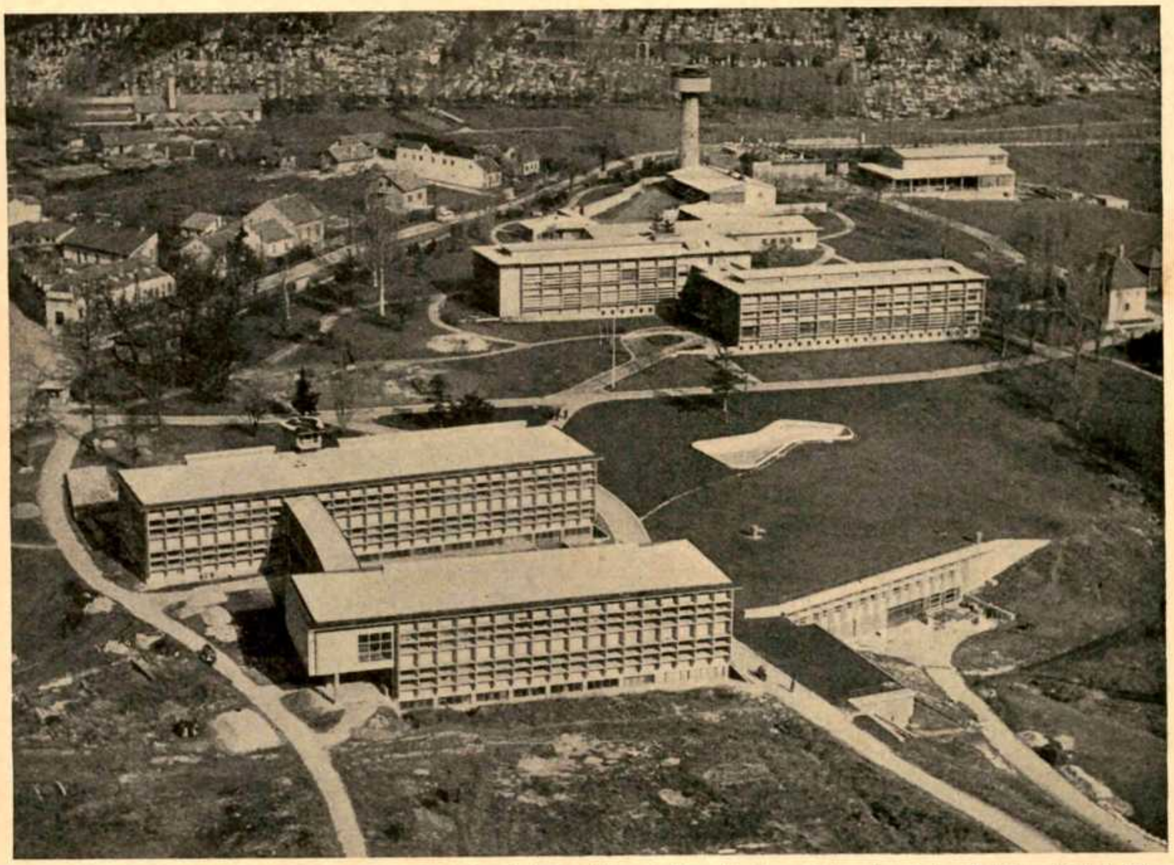

Fig. 1. The Rudjer Bošković Institute. The physical and chemical laboratories with the service and workshop buildings behind. The cyclotron house is underground on the right, the natural formations providing adequate screening

1950 to build its own cyclotron for the investigations in nuclear physics as well as for specialized techniques in the application of radioactive isotopes. A group of young engineers, therefore, after seeing some cyclotrons in Europe, made a detailed plan for a cyclotron to be constructed by themselves. This cyclotron will be the biggest machine for nuclear research in Yugoslavia, planned and built within the country, and with most of the instruments provided by domestic industry. The deuteron beam is expected to have an energy of 16 MeV. The cyclotron is to be a variable energy machine.

Two experimental groups for research on nuclear structure have been formed; their work will centre around the cyclotron and the 200 kV. neutron generator. In addition, there is a theoretical department which is working on the theory of fields, the study of nuclear structure, and the theory of metals.

From the beginning there has been a tendency to manufacture as much of the apparatus as possible within the Institute. A well-equipped Electronics Department was therefore organized as soon as the Institute was founded. Various types of counters, scalers, as well as other apparatus for nuclear research work have already been made. Work on transistors is also in progress.

There are two groups for physical chemistry: one dealing with structure analysis, the other with technological problems, especially those concerning nuclear raw materials. Great pains are being taken in the production of semi-conductors and of other crystals which are of importance to industry. New

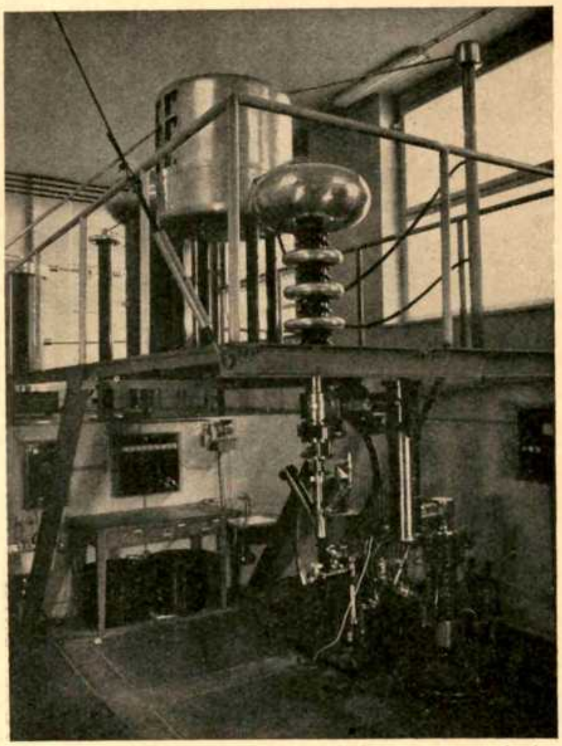

Fig. 2. One of the accelerating machines in the pure physics section

methods for the study of chemical processing problems are being introduced. Work in the tracer laboratory has been going on for three years in collaboration with the biology department, primarily on the compounds labelled with carbon-14.

Besides these investigations with weak radioactivities, a group for radiochemistry has been formed which will study materials which have been irradiated with the cyclotron and the application of radioactive isotopes in chemistry.

The basic task of the biochemical department is the synthesis of protectors against radiation, and recently emphasis has been laid on antibiotics. Investigations with labelled organic compounds are also in the biochemistry programme.

The research work in biology is mainly concerned with basic effects of radiation on living organisms, single-cell organisms and viruses being studied on one hand, and complex organisms on the other. Some of the biological work was begun in the Medical Institute of the University of Zagreb, and is now being continued in the Department of Biology.

The Scientific Council has always believed that the Institute and the University should be united by common efforts in research work as well as in the training of young scientists. In 1953 the University and the Institute Council decided to unite their efforts in the fields of work common to them and a postgraduate school was organized in the Institute in 1957.

The Institute is financed by the Federal Atomic Energy Commission, which also approves the annual research plans and co-ordinates work with that of other institutes in the country. Industry and other institutions, besides the Commission, support research work outside the field of nuclear energy.

At present about 400 people are working at the Institute. The number of scientific personnel is about 140 and it is hoped that this will increase next year. Technical staff working in the laboratories number about 60, and there are about 60 workers employed in the Institute workshops. Eventually the Institute will employ about 600 people.

Some experts of the Great Powers may look sceptically upon the efforts of small countries. Certainly, we cannot enter the race in big technical undertakings in the field of nuclear energy and we do not wish to. Our intention is to take part in fundamental research and to help build a solid basis for peaceful applications. But still more than this, the present state of the world, split into armed camps, has disrupted the internationalism of science. In this situation, on the verge of the suicide of the whole of mankind, the renaissance of a universal spirit is an aim, in the realization of which small countries like Yugoslavia can help a great deal.

NEWS and VIEWS

Research Association of British Rubber Manufacturers: Dr. J. R. Scott

The recent announcement that Dr. W. F. Watson has been appointed director of research of the Research Association of British Rubber Manufacturers might suggest that the rubber industry would be losing the services of Dr. J. R. Scott, but his many friends will be glad to know that this is not the case, because he is to be appointed to the newly created post of scientific adviser to the Research Association. Those who have followed the advance of international standardization will have realized how much progress has been made by Committee *ISO/TC/*45, on Rubber, of the International Organization for Standardization. This has been largely due to the painstaking work which Dr. Scott has put in as leader of the United Kingdom delegation. The patient and well-informed manner in which he dealt with international differences in opinion serves as a model of diplomacy which could well be followed by others. He is expected to lead the delegation to the next meeting, to be held in the United States in the autumn of 1959. As Dr. Scott will not be retiring in the near future, it is sufficient to note that he has already had thirty-five years service with the Association, and that he was the second holder of the post of director of research, succeeding the late Mr. B. D. Porritt on the latter's death in 1940.

Dr. W. F. Watson

Dr. W. F. Watson, who has been appointed third director of research, was born in Fifeshire in 1923 and obtained his Ph.D. when he was twenty-two, working at the University of Aberdeen under Prof. (now Sir Harry) Melville. He studied the theoretical treatment of copolymerization kinetics, the retardation and inhibition of polymerization reactions, the polymerization of methyl methacrylate initiated by its own polymer, and the diradical nature of photochemical and thermal polymerization. His work at Aberdeen was followed by a two-year postdoctorate fellowship at the University of Minnesota, sponsored by the United States Office of Naval Research, involving the absorption spectra of highly purified chlorophyll, for which he was awarded the D.Sc. degree of the University of Aberdeen at the age of twenty-six. His present work at the British Rubber Producers' Research Association is especially notable for studies of the way in which mechanical energy can be used to rupture molecular linkages, and he was the first to prove that this process occurred under the conditions obtaining in the mastication process. This development has opened up possibilities of obtaining interesting new materials, which have been confirmed on a commercial scale, and no doubt Dr. Watson will be continuing this work, as well as developing his novel single-rotor rubber mixer, at the Research Association.

Geology at the Imperial College of Science and Technology: Dr. John Sutton

Dr. John Sutton, reader in geology in the University of London, has been appointed to the University chair of geology at the Imperial College of Science and Technology, London, vacated three years ago by Prof. H. H. Read, whose work is described in *Nature*, 176, 490 (1955). Dr. Sutton has been associated with the Imperial College throughout his career as undergraduate, postgraduate research student, lecturer and reader—with a non-academic interruption by service in the Royal Electrical and Mechanical Engineers separating the first two stages. His early research work, done in collaboration with Dr. Janet Watson (Mrs. Sutton), dealt with the structural, metamorphic and plutonic history of the most ancient rocks, first of the Lewisian of the Scottish Highlands and then of the basement of East Africa. During the past decade, Dr. Sutton has built up at the Imperial College a research school concerned with the investigation in great detail of the structural history of the Moine Series of the Northern Highlands. Under his leadership, the complex history of this famous group of rocks has been patiently unravelled by meticulous field-work over considerable areas east of the Moine Thrust, and a firm foundation has been laid for a complete structural synthesis of Britain's most extensive formation. Agreeable to the definition of geology as earth-history, this work is marked by an appreciation of the importance of the timing of events in the production of crystalline schists. Under Dr. Sutton's direction in the field and the laboratory, a continued development of fundamental research in the metamorphic and plutonic rocks can confidently be expected at the Imperial College.

Seals and Nets

In its last annual report the Nature Conservancy reluctantly accepted the desirability of experimenting in strictly limited measures of control of the Farne Island grey seal population and recommended, as an experimental and interim measure, that further increases in the grey seal should be limited by an annual cull of 300 calves, if authorized by the Minister of Agriculture, Fisheries and Food by Order under the Grey Seals Protection Act, 1932. It also recommended continuation of research and observations on seals as at present and a new attempt, sponsored by the Scottish Home Department, to discover means of protecting nets against seals. Such an Order was laid before the House of Commons on July 10 and on July 28 a motion against the Order was made by Mr. A. Blenkinsop, who, in asking what the Government was doing to encourage further research into the problem and to strengthen nets, alleged that it had refused a grant to the Nature Conservancy to enable it to carry out this research work more effectively. Widely varying views were expressed in the debate, in which the risk of exterminating the grey seal, as had happened on the north Cornish coast, was recognized by supporters and opponents of the Order. The motion was withdrawn in view of the explanation by Mr. J. B. Godber, Joint Parliamentary Secretary to the Ministry of Agriculture, Fisheries and Food, that no final decision had been taken as to the merits of culling as a means of controls and his undertaking to look into the possibility of assistance to further research work.

Committee on Grants to Students

The Ministry of Education and the Scottish Education Department announce that the Committee on Grants to Students set up recently under the chairmanship of Sir Colin Anderson (see *Nature*, 182, 20; 1958) is now ready to receive written evidence. Any interested persons or bodies are invited to submit a memorandum to the secretaries (for England and Wales, Mr. D. Neylan, Ministry of Education, 14 Cornwall Terrace, London, N.W.1, and for Scotland, Mr. G. A. T. Hanks, Scottish Education Department, St. Andrew's House, Edinburgh 1), if possible not later than November 30. The terms of reference of the Committee are: "to consider the present system of awards from public funds to students attending first degree courses at universities and comparable courses at other institutions and to make recommendations". Among the questions which the Committee will be considering are the kinds of awards to be made from public funds, the method of selecting students for such awards and the principle of the hardship test required by the law as it now stands.

Adventures in Science

The Smithsonian Institution has just published a new popular science booklet for young people, designed to show "that science can be exciting and that science can be fun". Entitled "Adventures in Science at the Smithsonian", the illustrated 24-page booklet tells about a few of the scientific milestones that have marked the progress of civilization and shows part of the outstanding role that the Smithsonian has played in the advancement of science since its founding in 1846. Planned to appeal primarily to children in junior schools, "Adventures in Science" not only presents information about many different sciences in simple, easy-to-read form but is also extensively illustrated in colour with objects from the Smithsonian's collections. The booklet can be read in two ways—from front cover to back, or from back cover to front. The natural sciences occupy the first half of the publication, while the physical sciences and engineering occupy the second half. If the reader begins at the back page, he starts in the present—"Tracking Earth Satellites"—and reads back into time. If he starts at the front, he journeys from "The Dinosaur Age" to the present. The authors, E. John Long and George Weiner, have simplified the often prolix terminology of science. For example, the subject of anthropology is covered in the section entitled "Searching for Cave Men", and astronautics, or rocketry, is discussed in "Into Space". The price for single copies is 25 cents.

Laws in Social Science

One of the main points made by Sir Alexander Carr-Saunders in his recent Eleanor Rathbone Memorial Lecture at the University of Liverpool ("Natural Science and Social Science". Pp. iv+15. Liverpool University Press, 1958. 3*s*.) is that, despite many attempts by social scientists to discover laws and law-like correlations by using the procedures of the natural sciences, "nothing remotely resembling a law of the natural sciences has yet been produced". Carr-Saunders agrees with J. S. Mill who, in his "System of Logic", subjected the possibility of using natural science procedures in the social sciences to exhaustive analysis. His conclusions were that, because of what Mill called "the complication of causes" and of the impossibility of insulating the variables concerned from the large influences of extraneous factors, no laws can be established in the social sciences in this way. It is not surprising that none has been discovered. "If such laws could be discovered they would appertain rather to a world of ants than to a world of men."

Work of Sir Edmund Whittaker

The *Proceedings of the Edinburgh Mathematical Society* of June 1958 is a worthy memorial to the late Sir Edmund Whittaker. An obituary notice by D. Martin is followed by papers on various aspects of Whittaker's work: harmonic functions (G. Temple); automorphic functions (R. A. Rankin); algebra and numerical analysis (A. C. Aitken); relativity (J. L. Synge); physics and philosophy (J. McConnell). Few mathematicians of our time have matched Whittaker's clear vision and deep knowledge of the whole field of modern mathematics. To young men he was always an inspiration, and to ensure that this inspiration shall not be entirely lost, his family has founded a Whittaker Memorial Prize for the encouragement of young mathematicians in Scotland; details are given in this number of the *Proceedings*.

The National Museums, Ceylon

The annual reports of the National Museums in Ceylon for 1956 and 1957 (pp. 20+5 plates. 70 cents. Pp. 23+2 plates. 70 cents. Colombo: Government Publications Bureau, 1957 and 1958) record steady but not spectacular progress in all departments. The most outstanding discovery yet made in Ceylon was that of a Stone Age kitchen-midden in the Balangoda District containing a number of ceremonial burials in a flexed position. The skull is being reconstructed at the American Museum of Natural History and it is hoped that a carbon-14 test will be carried out in Britain. The Museum Week sponsored by Unesco in October 1956 was duly observed and important and instructive talks were given on Radio Ceylon.

Museum of Applied Science at Victoria

The annual report of the Museum of Applied Science of Victoria for the year ended June 30, 1957 (pp. 30. Melbourne: Museum of Applied Science of Victoria, 1958), is up to date, as it opens with a photographic illustration of a model of a space satellite now included in the museum collections. Another fascinating exhibit is a model of an oxygen atom with its twenty-four particles in rapid motion. Special exhibits were also displayed for the benefit of visitors to the Olympic Games in Melbourne in 1956. A series of large portraits of eight famous scientists, ranging from Galileo to Einstein, attracted much attention. The Museum has been fortunate in achieving two of its objectives of many years—the provision of a convenient store of adequate size and a hoist for moving massive objects to and from the main floor.

Technical Information Systems

The Office of Scientific Information of the National Science Foundation has issued under the title "Non-Conventional Technical Information Systems in Current Use" (pp. v+43. Washington, D.C., 1958) a report briefly describing twenty-five representative systems of new design, covering the principles of operation of each system, the equipment and man-power required, the size of the group served and of the file and its rate of growth, with bibliographical references to any published information on the system. The report is purely factual and includes no comment or criticism of the systems described. Among these are the mechanized searching system for patents on steroid compounds used at the United States Patent Office, the hand-sorted punched-card file for geochemistry maintained at the United States Geological Survey, the mechanized indexing system for literature in pathology and biochemistry, using the *IBM* 101 statistical machine at the Documentation Centre of the Schering Corporation, and the 'peek-a-boo' system of co-ordinate indexing used, for chemical compounds tested, by the U.S. National Institutes of Health cancer chemotherapy programme.

Egyptian Scientific Institutions

To assist men of science who are interested in the development of science in Egypt, the Middle East Science Co-operation Office of Unesco has published a survey of all the scientific institutions in Egypt (pp. 149. Cairo: Unesco Science Co-operation Office, 1957). The institutions listed are concerned with teaching and research not only in the fields of pure science but also in engineering, agricultural and medical sciences. With the exception of various scientific societies, all these institutions are government bodies. The survey explains how scientific institutions are controlled by the Ministry of Education and also gives a clear account of the national educational system. Among the institutions described are the universities, the Science Council, the National Research Centre, Desert Institute, Atomic Energy Commission, Ministry of Agriculture, Ministry of Industry (Geological and Mineral Research Department, Mines and Quarries Department), Ministry of Commerce (Chemical Department), Ministry of Public Works (Nile Control Department), Ministry of Public Health, Ministry of War, the Egyptian Sciences Association, l'Institut d'Egypte, and the Egyptian Academy of Science. Names of leading members of the staffs of these organizations are included.

University Theses

The Committee of the University and Research Section of the Library Association set up in 1952 a small sub-committee to investigate ways and means of publishing detailed information about the contents of theses accepted in British universities and increasing their availability. A report by this sub-committee, published in the *Library Association Record* (60, 13; 1958), expresses the opinion that the arrangements with regard to theses are generally too haphazard to be entirely satisfactory and that it should be possible for the universities to adopt a uniform plan to render such information more comprehensive and regularly available. The sub-committee was aware of the "Index to Theses accepted for Higher Degrees", published annually by Aslib since 1950–51, and noted a scheme operated by University Microfilms in the United States in which some eighty universities and associated institutions participate, but inquiries as to the feasibility of a similar scheme in the United Kingdom met with a disappointing response. The report summarizes the difficulties which must be overcome in regard to accessibility or secrecy, copyright, etc. It stresses the importance both of the Standing Conference of National and University Libraries persuading British universities to accept a desirable standard of availability and also of the work of the Department of Scientific and Industrial

Research in improving communication between the universities and government research establishments. A new commercial but selective scheme for microfilming dissertations is briefly described, which could be adapted to meet the requirements of individual universities and eliminates the need to charge a microfilming fee.

Computer Training Centre

Bradenham Manor, the property of the National Trust, has been leased to the British Tabulating Machine Co., Ltd., for use as a Hollerith Computer Training Centre. On July 24 the Centre was opened by Lord Halsbury, managing director of the National Research Development Council, who said that the old idea that a trainee learnt his job by copying what his predecessor could be seen to be doing has no room in the field of computer training. Training on modern, almost academic, lines is what is required and such training the Bradenham centre would provide. Some 3,000 people per annum undergo training in the use and applications of mechanized accounting equipment at the five educational and training establighments maintained by the British Tabulating Machine Company's resources. Other facilities will become available as the result of the proposed merger with Powers-Samas.

Rugby School Natural History Society

P. R. M. Pattisson, a scholar at Rugby, has carried out experiments to determine the reactions of *Gammarus* sp. to water currents. The apparatus consisted of a double horseshoe-shaped trough about 7 ft. long, containing water circulated by a paddle-wheel. The water was about ½ in. deep. The speed just above the bottom was measured by timing the movement of a small piece of pumice-stone weighted with 'Plasticene' over a measured distance. Experiments were carried out in the clear straight side of the trough which was marked off in inches and showed that the swimming speed increases linearly with the current. While swimming, *Gammarus* is able to gain ground for any current speed. The rate of increase in swimming speed is less than the corresponding increase in current; the animal gains ground more slowly at the higher current speeds. The respiration of *Tubifex* and *Culex* sp. has been investigated by A. M. Roberts, another scholar at Rugby. The Report for 1957 (Report of the Rugby School Natural History Society for the year 1957. Pp. 28+1 plate. (Ninety-first issue.) Rugby: Rugby School Natural History Society, 1958) contains details of these two investigations as well as reports of all the many sections affiliated to the Society. Their activities do credit to scholars and staff.

Circulation in the Black Sea

It is usually assumed that the Black Sea in its deeper part (below 200 m.) consists of stagnant fœtid waters rich in hydrogen sulphide. This led to a suggestion that the Black Sea may be utilized as a depository for the atomic waste. Arguments showing the erroneous conception of 'buried' bottom waters of the Black Sea are brought forward by V. A. Vodyanitzky (*Priroda*, 2, 46; 1958), who presents strong evidence in favour of the existence of convexion currents producing a vertical circulation of the waters of the Black Sea.

Geological Age

Eduard Suess in his "Face of the Earth" postulated the existence of "the most ancient vertex of the Eurasian folds" occupying the mountain-crescent fringing Lake Baikal in the south. This vertex, formed by folded mountains of the Pre-Cambrian age, fringes the southern border of the stable "Augara Land'. As outlined by V. T. Mordovsky (*Priroda*, 3, 85; 1958), this conception, based on the original works of I. D. Chersky and V. A. Obruchev, must be completely reconsidered in the light of subsequent interpretations carried out by L. de Launay, M. M. Tetiaev, A. N. Churakov and N. S. Shatsky. According to the Tectonic Map of the U.S.S.R. edited by Shatsky and published in 1957, the exposed portions of the Pre-Cambrian 'Augara Land' are exposed only in the Anabar, Sayan and Aldan massifs, while its remaining parts are covered by later stratified unfolded deposits. At the same time, the greater part of the area of the alleged 'ancient vertex" must be considered to be formed by rocks folded during the Baikalian orogenesis (Early Cambrian to late Proterozoic) and Caledonian orogenesis (late Palæozoic). "Thus", writes Mordovsky, "the ancient vertex of Asia, as understood by Chersky, Obruchev and Suess, does not exist. The Siberian Platform, together with the Anabar massif and the Aldan shield, is one of the most ancient areas in the northern Asia".

Root–Shoot Relationships

The effect of removing part of the root system on the subsequent growth of the root and shoot systems has been investigated by E. C. Humphries (*Annals of Botany*, N.S., 22, 251; 1958). When some 50 per cent of the roots of barley and rye were removed, the growth-rate of the remaining roots was the same in intact plants; but the growth-rate of the shoot decreased progressively as more and more roots were removed. When the number of roots removed exceeded 50 per cent, there was a decline in the rate of root growth, though this was less marked than that of the shoot. Comparable results were obtained in experiments in which the lateral roots of tomatoes were removed; but in this species a 40 per cent removal of laterals was critical for maintenance of growth in the remaining root system. The author also reports that the uptake of potassium, in barley plants with parts of the root system removed, was closely proportional to the increase in dry-matter when the nutrient supply is not limiting; but, with low nutrient supply, the potassium uptake was less than the dry-matter increase.

Auxins in Bean Embryo Development

M. Furuya and K. Soma have contributed some interesting new observations on the effects of various auxins on the development of bean (*Phaseolus vulgaris*) embryos grown *in vitro* (*J. Fac. Sci. Univ. Tokyo*, Sect. 3, 7, 163; 1957). Dormant embryos were removed from the cotyledons and cultured either intact, or as four separate regions or segments, namely, the apical portion, including the first foliage leaves, the hypocotyl, the short basal transitional region, and the radicle. White's solution, with the vitamins omitted, was used, together with individual additions of β-indolylacetic acid, sodium 2,4-dichlorophenoxyacetate (2,4-D) and sodium α-naphthylacetate at different concentrations (10^{-3}–10^{-11} mole per litre). Liquid and solid media were both used and cultures were maintained either in continuous darkness or in 12 hr. of light a day. Measurements of growth and of morphological and histological developments are recorded and illustrated. Among the abnormal developments observed, especially at the higher concentrations of auxin, were the formation of tumourous and callus tissues, disorganizations of normal tissue differentiation, and formation of adventitious roots, but no induction of buds is reported. Attention is directed to the different reactivities of different regions of the embryo according to concentration of auxin and cultural conditions. The three auxins tested had generally comparable effects on the growth and differentiation of embryos, namely: complete inhibition of growth; inhibition in meristematic tissues, including the procambium, but extensive activation in mature tissues; activation in meristematic tissues, including the formation of adventitious roots; and regulation of growth-rate, these being in the order of decreasing auxin concentration. The results obtained are discussed fully in relation to contemporary views on auxin action.

Control of Dollar Spot Disease (*Sclerontinia homoeocarpa*)

Trial work with a new fungicide, cadmium chloride/urea, has recently been completed by the Sports Turf Research Institute (*Sports Turf Bulletin*, 41, April–June, 1958) for the control of dollar spot disease. Outstanding results were obtained from seven (monthly) applications of the fungicide on the bowling green of the Briton Ferry Steel Co., Ltd., in Glamorgan. The green (originally of sea-marsh origin) still contains a proportion of the original sea-side bents and fescues with an admixture of annual meadow grass. Although in good condition each summer, the fescue has been progressively weakened by attacks of dollar spot disease. Work with the cadmium chloride/urea fungicide started in April 1957. Further applications at the same rate were made in May, June, July, August, September and October. The fungicide spray was combined with the regular application of fertilizer—three evenly spaced applications of fertilizers containing a high proportion of readily available nitrogen. When examined in November, the turf was found to be free from visible signs of the dollar spot disease. There were no signs of other diseases such as *Fusarium* patch and *Corticum*. The same fungicide was effective in controlling dollar spot disease on bowling greens in Yorkshire and Lancashire. On other greens good control of the disease has been obtained, but where an insufficient number of applications has been made, the disease has re-appeared later.

Colour Changes in Teleosts

The control of colour changes in the lower vertebrates, including the teleostean fishes, has received a considerable amount of attention, and various different and even conflicting theories have been put forward to explain it. In a recent study, Priscilla Rasquin (*Bull. Amer. Mus. Nat. Hist.*, 115; 1958) has approached the problem from a different aspect and, instead of studying one or two species in detail, has surveyed a wider field. The memoir is divided into two separate parts. Part 1 is the study of the histomorphology of the pineal complex of thirty-three species of teleosts, including freshwater and marine forms. In general, the extent of the specialization of the pineal organ (epiphysis) is related to the degree of transparency of the overlying tissues and it exhibits a wide range of variation. Experiments on pinealectomy in *Astyanax* show no appreciable effect upon pigmentation, and while there is some evidence of secretory activity in the pineal organ in some species there is none of an endocrine function. Part 2 is a study of the effects of the injection of adrenalin in thirty-five different species and also of intermedin and a series of mammalian pituitary hormones. With adrenalin three groups can be distinguished in which there is: (1) a concentration of granules in the melanophores; (2) a concentration in the internal melanophores only; (3) no effect. In all species there was a response in the lipophores to adrenalin but in one group the response was dispersion and in the other concentration of the pigment granules. With intermedin all species showed dispersion in the lipophores, but the melanin granules in the chromatophores in four species showed concentration and others gave no reaction. These observations show the need for further investigation, for the responses in one species need not be duplicated in another, and it is dangerous to argue from the particular to the general. Some of the photomicrographs in the ten plates are not good, and most would be more useful if labelled.

Continuous-writing Streak Camera

An improved streak camera for the study of fast self-luminous events has been developed by Beckman and Whitley. It is intended primarily for the study of explosions, shock tube, spark discharge and similar phenomena. Standard 35-mm. film, arranged for daylight loading and unloading, is used. The image is swept on to this film by a rotating triangular mirror driven by a high-speed turbine. Several types of these are available—the fastest one, ranging from 200 to 5,500 revolutions per second, is driven by helium gas. This arrangement produces a maximum writing rate of approximately 8 mm./μsec.; and a maximum time resolution, using a 0·004-in. wide slit image and film having a resolution of 75 lines per mm., of $2 \cdot 5 \times 10^{-8}$. The camera has a control equipment which includes an events-per-unit-time meter for accurate measurement of the mirror speed to provide a determination of writing-rate; mirror-speed adjustments; and controls for the capping shutter and the explosive-actuated blast shutter, used to prevent rewriting in the case of events of long duration.

Cometary Spectra

In a recent paper entitled "Molecules in the Solar System" (*Cont. Dominion Astrophys. Obs., Victoria, B.C.*, No. 51), A. McKellar discusses gaseous molecules in comets and in planetary atmospheres, including that of the Earth. The spectra of comets are characterized by the occurrence of emission bands of molecules superposed on a background of reflected solar radiation. The spectra of comets are generally solar when their heliocentric distances exceed 3 astronomical units, but emission bands appear as the comet approaches the Sun. Generally speaking, heliocentric distance has proved the most useful parameter in describing the behaviour of the molecular emissions.

Dealing with the source of cometary gases, reference is made to Whipple's cometry model (*Astrophys. J.*, **111**, 375 ; 1950, and **113**, 464 ; 1951), which envisages the nucleus as a conglomeration of frozen solids, such as water, ammonia, methane, carbon dioxide or carbon monoxide, and possibly other materials, combined with meteoric matter, all initially at a temperature below 50° K. As the comet approaches the Sun, the frozen solids vaporize and so provide the parent molecules which, upon photo-dissociation, give the radicals the spectra of which we observe. Donn and Urey have suggested a modification of Whipple's model (*Astrophys. J.*, **123**, 339 ; 1956) to include both stable and reactive molecules, yielding radicals which could lead to actual chemical explosions to explain observed cometary activity. They give examples of a number of laboratory experiments involving NH and azides, OH and hydrogen peroxide, etc., that could conceivably occur if concentration of the necessary radicals and other molecules were present in the matrix. It appears, therefore, that solar radiation or corpuscles need only act as a trigger for the strongly exothermic reactions which provide their own excess of energy in the explosion.

Proceedings of the Royal Institution

The *Proceedings of the Royal Institution* are to be published three times a year in future instead of annually ; one advantage of the new procedure will be that the discourses will appear in print soon after their delivery. Thus, Vol. 37, Part 1, No. 165, which is the first to appear under the new arrangement, opens with the discourse on gemstones given by Sir Lawrence Bragg on January 31, 1958, and includes five other discourses given before Easter. It is also intended to publish once a year a famous discourse given at the Royal Institution a hundred years ago. The *Proceedings* are available to non-members at 8*s*. 6*d*. per issue, or 21*s*. a year, from January 1, 1959 (from the Royal Institution, 21 Albemarle Street, London, W.1).

"Rejection of the Peroxide Accumulation Hypothesis of Isoniazid Action"

Dr. Frank Winder, Laboratories of the Medical Research Council of Ireland, Trinity College, Dublin, writes : "In a communication under this title in *Nature* of April 26, p. 1203, Holmes and Rubbo state that 'Sodium nitrite . . . reduces free peroxide, and reacts rapidly with the catalase–peroxide complex . . .'. The first portion of this statement is true only when the *p*H is well on the acid side. To check this, 50 μgm. per ml. hydrogen peroxide were incubated with 500 μgm. per ml. sodium nitrite for 24 hr. in phosphate buffers over the *p*H range 5–7. The peroxide was then estimated by methods which did not involve acidification, for example, by using peroxidase or luminol. The nitrite caused no significant destruction of the peroxide in any of these buffers".

The Night Sky in September

New moon occurs on Sept. 13d. 12h. 02m. u.t., and full moon on Sept. 27d. 21h. 43m. The following conjunctions with the Moon take place : Sept. 4d. 21h., Mars 0·5° N. ; Sept. 16d. 07h., Jupiter 0·2° N. ; Sept. 19d. 15h., Saturn 3° S. In addition to these conjunctions with the Moon, Mercury is in conjunction with Venus on Sept. 5d. 02h., Mercury being 2·1° S., Venus with Regulus on Sept. 8d. 17h., Venus being 0·7° N., Mercury with Regulus on Sept. 10d. 09h., Mercury being 0·0° N., and Mercury with Venus on Sept. 18d. 06h., Mercury being 0·3° N. Mercury is favourably placed for observation during the first fortnight of the month, and is a morning star, rising at about 4h. ; during this period its stellar magnitude increases from +1·6 to −0·7. Venus is also a morning star, visible low in the south-east before sunrise. It rises at 3h. 30m., 4h. 10m. and 5h. 0m. on September 1, 15 and 30, respectively ; its stellar magnitude is −3·3. During the month its distance from the Earth increases from 149 to 156 million miles and the visible portion of the apparent disk from 0·947 to 0·982. Conditions for observation are rather unfavourable at the end of the month. Mars rises at 21h. 20m., 20h. 35m. and 19h. 45m. at the beginning, middle and end of the month, respectively. Its stellar magnitude increases during the month from −0·5 to −1·1, its distance from the Earth decreasing from 70 to 56 million miles. Mars enters Taurus on September 1, and continues moving eastwards among the stars ; it is south of the Pleiades on September 13–16. Jupiter is too close to the Sun for satisfactory observation. Saturn sets at 22h. 30m., 21h. 35m. and 20h. 40m. at the beginning, middle and end of the month, respectively ; it is near θ Ophiuchi. It has a stellar magnitude of +0·7 and a distance of 935 million miles from the Earth on September 15. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich : Sept. 7d. 01h. 46·6m., 115 Tau. (*R*) ; Sept. 9d. 02h. 12·8m., λ Gem. (*D*) ; Sept. 9d. 03h. 02·0m., λ Gem. (*R*) ; Sept. 21d. 19h. 08·9m., ρ Sgr. (*D*) ; Sept. 22d. 23h. 18·2m., β Cap. (*D*). *R* and *D* refer to reappearance and disappearance, respectively. The autumnal equinox occurs on Sept. 23d. 13h.

Announcements

The nineteenth national conference of the Council for the Preservation of Rural England, on "Rural Problems of the Moment", will be held in Cheltenham during October 16–18. Further information can be obtained from the Secretary of the Council, 4 Hobart Place, London, S.W.1.

The first electronic computer exhibition in Europe will be held at Olympia, London, during November 28–December 4. A business computer symposium will be held concurrently. Further information can be obtained from Mrs. S. S. Elliott, 11/13 Dowgate Hill, London, E.C.4.

The Institute of Physics, one of the constituent bodies of the British Nuclear Energy Conference, is arranging a Symposium in London on "Nuclear Fuel Cycles", on January 22 and 23, 1959. The papers which have been invited cater mainly for those working in the field, and will deal with the applied physics aspects of the fuel cycles which form the basis of the immediate nuclear power programme. Application to attend the Symposium should be made to the Secretary, Institute of Physics, 47 Belgrave Square, London, S.W.1. Proceedings of the Symposium will be published in the *Journal of the British Nuclear Energy Conference.*

COLONIAL TERRITORIES

THE report on the Colonial Territories for 1957–58* provides the usual conspectus of political, economic, financial and social developments in these territories against which the achievements to be recorded in greater detail in "Colonial Research, 1957–58" are to be considered. Some of this material, outlined in the 22-page chapter entitled "Research and Surveys", has also appeared in reports from various Colonial research organizations already noted in *Nature*, and for this reason, while this chapter in the present report is the one of most direct interest to the scientist, consideration of research in the Colonial territories is deferred until the fuller report, "Colonial Research, 1957–58", is published in due course.

Recruitment through the Colonial Office continued at the same general level as last year, but recruitment for the Federation of Malaya was gradually transferred to the High Commissioner for that territory. About the same number of administrative and medical officers were appointed as in 1956, but the number of educational appointments increased and the number of civil, mechanical and electrical engineers and agricultural officers recruited decreased. The total overseas appointments through the Colonial Office was 1,296 as compared with 1,286 in 1956, leaving 1,385 unfilled vacancies at the end of 1957, compared with 1,461 at the end of 1956. Training courses and attachments were arranged for 2,925 men and women in the service of overseas governments, compared with 2,752 in 1956.

The recession in world commodity prices in 1957 had little effect on the territories, and taking the year as a whole the prices of most Colonial products, except copper and sisal, were as high or higher than in 1956. Output continued to rise and the total gross domestic product is estimated as some 4 per cent above the 1956 level of about £3,100 million, the greatest proportionate increase being in the West Indian territories, where the value of exports rose by 12 per cent compared with a general increase of 2 per cent. The volume of exports of primary products rose only slightly.

After two years experimental work in the Western Region of Nigeria, 2,000 farmers were trained in their villages in spraying against capsid pest of cocoa. The extensive spraying campaign against blackpod continues, but control of swollen shoot disease has lost ground. Farmer-training in the control of blackpod and capsid on cocoa continued in the Eastern Region and about one-third of the 8,000 cocoa farmers in the Southern Cameroons sprayed their cocoa against blackpod disease with excellent results. In Kenya use of parathion sprayed from aircraft at night showed great promise for control of infestation by the Quelea bird (Sudan Dioch), and use of dieldrin for control of white stem borer of coffee and of DDT/BHC dust for cotton pests continued to spread in Tanganyika. A programme of research and control of the serious incidence of insect pests of cotton in the Aden Protectorate is in progress. Research continued into the most suitable types of fertilizers for individual soils and crops, and use of fertilizers continued to increase. The territories continued to receive expert assistance under the Expanded Technical Aid Programme. Two teams of experts visited Jamaica, Trinidad, British Honduras and Dominica to survey costing methods and research needs, respectively, of the citrus industries.

Effective control of the major epizootic diseases continued in the West African territories, but trypanosomiasis continues to be a serious problem in East and Central Africa.

Public expenditure on development continued at a high rate and expenditure from Colonial Development and Welfare Funds rose by about £1 million, but was still only about three-quarters of the annual average available under the 1955 Colonial Development and Welfare Act. New development plans were drawn up in Jamaica and Trinidad, and during the year power supplies became available for Kenya from the Owens Falls hydro-electric plant in Uganda. A new road from Western Uganda to the Belgian Congo was completed, work begun on the construction of a deep-water harbour in Barbados and the first hydro-electric plant in British Guiana came into operation.

Facilities for education increased in nearly every territory, as did the numbers using them. Of the 3,400 students in the two universities and three university colleges, 1,075 were in the University of Hong Kong, 749 at University College, Ibadan, 710 at the University College of East Africa, Makerere College, and 566 at the University College of the West Indies. Teaching and administrative staffs have also expanded, and University College, Ibadan, has now a fully established medical school with a new teaching hospital. In co-operation with the Nigerian College of Arts, Science and Technology, which was formally opened in November, a faculty of engineering is being established, and the University College of the West Indies is considering the establishment of a faculty of agriculture. Allocations to these university institutions under the Colonial Development and Welfare Funds for capital expenditure for the 1955–60 quinquennium total £6,853,000. The Royal University of Malta was the subject of an investigation by a Royal Commission, and the Governments of Kenya, Uganda, Tanganyika and Zanzibar jointly published a paper outlining their future plans for higher education.

Progress in preventive and social medicine has been in two main directions: by a widely developed attack on communicable disease by mass campaigns of treatment, immunization or destruction of insect vectors; and by much greater attention to the needs of the family and the individual through the medium of health centres, specialized clinics and an elaboration of domiciliary care. Control and ultimate elimination of malaria still constitute a major challenge, but the effects of a more enlightened outlook on leprosy are apparent in the recognition of the need for social rehabilitation of those cured.

Of the 9,923 Colonial students in the United Kingdom and the Irish Republic at the end of 1957, 1,298 held scholarships and 2,709 were at universities. Of the total, 3,360 were from West Africa and 3,096 from the West Indies; 867 were studying engineering, 745 medicine, 308 science, 228 economics, 89 agriculture and 69 dentistry. Tribute is again paid, here and in respect of information services, to the work of the British Council. It is estimated that 1,033,000 U.S. dollars will be spent on the United Nations Expanded Programme of Technical Assistance in the British territories in 1958 compared with 1,271,000 dollars in 1957. Under the Fulbright Agreement nine American teachers were posted to schools in Western Nigeria, St. Helena, Antigua, Grenada, Jamaica and Montserrat, and nine senior research workers attached to university and research institutions in East Africa, Northern Nigeria, Hong Kong, Jamaica and Trinidad, while two scientists continued research into the preservation of wild life in the game reserves of Uganda. Travel grants enabled lecturers from University College, Ibadan, the University College of the West Indies and the University of Malaya to visit the United States for research and to give lectures. An Overseas Visual Aid Centre has been established in London with the joint support of the Government and the Nuffield Foundation to further the use of visual and audio-visual aids in education.

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* Colonial Office. The Colonial Territories 1957–1958. Pp. xxv + 171. (Cmnd. 451.) (London: H.M. Stationery Office, 1958.) 9s. net.

SOLID STATE PHYSICS

CONFERENCE IN BRUSSELS

As part of the activities associated with the Brussels Universal Exhibition, a Conference on Solid State Physics and its applications to electronics and telecommunications was held in Brussels during June 2–7. The meeting had the patronage of the King of the Belgians and the support of the International Union of Pure and Applied Physics. It was regarded as appropriate because of the stress laid by many exhibitors on contemporary scientific achievements. After an introductory lecture by W. Shockley, the 750 participants from twenty-four countries divided up to listen to papers which were grouped in five parallel sessions throughout the six days of the conference.

It was inevitable that such a meeting would be dominated by discussions of the properties of semiconductors, their theory, and the main applications in transistors, phosphors and electroluminescence. There were also sessions on ferrites. Despite the extent of the field covered, its unity, so far as basic ideas are concerned, became very clear as the meeting progressed. This proved to be a stimulus to many participants, who regretted the large number of papers offered rather than the spread of topics.

The areas of activity in the field of pure semiconductors include equilibrium properties such as susceptibility measurements, transport phenomena, the study of barrier layers and surfaces, of noise, life-times and recombination, optical properties, the growth of, and imperfections in, single crystals, and the changes induced by irradiation. All these topics, and others on the more applied side, were discussed at this meeting, as they were at the last similarly international meeting at Garmisch in 1956 (see *Nature*, 198, 1156; 1956). A slight change of emphasis has, of course, occurred. For example, at Garmisch considerable interest was shown in the newly discovered phonon drag effect, which implies, for example, that long wave-length phonons exert a drag on the charge carriers, and contribute rather strongly to thermal conduction. Little was said about this effect in Brussels. On the other hand, the properties of electrons which are not in equilibrium with the lattice owing to the effects of an applied electric field—the so-called 'hot electrons'—received much more attention than they did at Garmisch, and this promises to remain an active field.

For example, J. Bok (École Normale Supérieure, Paris) reported attempts by thermionic emission experiments to obtain direct evidence of the temperature of hot electrons. S. H. Koenig (I. B. M. Watson Laboratories, Columbia University) emphasized again that the hot electron distribution function responds very rapidly (within less than 10^{-9} sec.) to changes in the applied field. In many aspects of these effects theory still lags behind experiment. This became particularly clear from a talk by R. Stratton (Metropolitan-Vickers Electrical Co., Manchester), who discussed theories of the dependence of electron mobilities on the electric field.

As the applied field is increased, the hole and electron temperature rise, and in due course breakdown occurs. In *p–n* junctions the breakdown is believed to be of the avalanche type. This was discussed for germanium by B. M. Wul (Lebedew Institute, Moscow). He showed that the coefficient of impact ionization for holes is about twice that for electrons. Recent work for silicon (Chynoweth, A. G., *Phys. Rev.*, 109, 1537; 1958) is of interest here for comparison. The properties of hot electrons may also be expected to affect the current–voltage relation of *p–n* junctions for high forward currents. This was discussed by A. K. Jonscher (General Electric Co., Wembley), the suggested form of the relation being $I^{1/2} = AV(V - B)$.

In this field of barrier-layer physics, attention was directed by several speakers to the measurement of the working temperature in the barrier (which has a pronounced effect on the properties of silicon and germanium rectifiers). Considerable interest was also shown in narrow germanium *p–n* junctions containing high concentrations (10^{18} to 10^{20} cm.$^{-3}$) of impurities. In such structures the Fermi-level can lie below the top of the valence band on one side, and above the bottom of the conduction band on the other side. This gives rise to stability against thermal shock, and to a forward current-voltage characteristic which exhibits negative resistance (for preliminary results, see Esaki, L. (Tokyo), *Phys. Rev.*, 109, 603; 1958). An incidental point of interest is that the direction of rectification is opposite to the usual one, and so is in agreement with that suggested in 1932 on the hypothesis of electron tunnelling.

It appears that semiconductor surfaces are being investigated increasingly by means of adsorption characteristics. The possibility of either mobile or localized adsorbed films of various kinds on germanium surfaces was envisaged by M. J. Sparnaay (Philips Research Laboratories, Eindhoven), and by H. Statz (Raytheon Co., Waltham, Mass.). Low-energy electron diffraction and work-function measurements were used by H. E. Farnsworth *et al.* (Brown University, Rhode Island) to study the structure and adsorption characteristics of clean germanium surfaces. He showed that surface atoms, displaced on a clean surface, appear to be restored to their normal positions by the presence of a chemisorbed oxygen monolayer. The effect of oxygen adsorption on the photoelectric sensitivity of bismuth films was discussed by R. Suhrmann (Hannover).

An interesting group of papers on silicon was submitted from the British Associated Electrical Industries group of companies. R. C. Newman and J. Wakefield (A.E.I. Laboratory, Aldermaston) pointed out the possibility of a connexion between the formation on silicon surfaces of etch pits on one hand and of silicon carbide on the other. The distribution of impurities in pulled silicon crystals was discussed, among other topics, in two papers (N. R. Howard ; P. Ransom, British Thomson-Houston Co., Rugby). H. F. Mataré (Sylvania Electric Products, Inc., Bayside, N.Y.) reported electrical experiments on bicrystals having known angles of misfit, and drew conclusions about the overlap of wave-functions of dangling bonds which occur at grain boundaries. Further information about these effects was expected at the meeting being held at Rochester, New York, at which a session is being devoted to grain boundaries and dislocations. An interesting aspect of crystal imperfections is their effect on mechanical damping. In silicon and germanium single crystals the damping usually shows two peaks when regarded as a function of temperature. The low-temperature peak at about two-thirds the melting point may perhaps be associated with the movement of dislocations. The high-temperature peak is probably connected with the motion of dissolved oxygen. A paper on these effects was read by P. D. Southgate (Mullard Laboratories, Salford).

Because of their applications to thermoelectric refrigeration a session was devoted to tellurides. The theory of remanent magnetization, important in connexion with magnetic recording tapes, was discussed by E. P. Wohlfarth (Imperial College of Science and Technology, London). Other applications which were considered included the use of impact ionization of impurities for low-temperature computing elements, applications of fluorescence to post office sorting problems, and several papers on transistor technology. As in the case of the earlier meeting at Garmisch, band calculations were discussed only incidentally. Impurity band conduction was mentioned somewhat more prominently—for example, in some speculations about the transition to metallic impurity band conductivity. The apparent absence of impurity band conduction down to 2° K. in some specimens of InSb was pointed out by E. H. Putley (Royal Radar Establishment, Malvern).

Other stimulating contributions, for example, in magneto-optics, are not mentioned here, since they are included in other conferences this summer. The proceedings of the Brussels meeting have been promised for the end of this year. Those of the 1956 Garmisch meeting are still expected.

P. T. Landsberg

STERIC EFFECTS IN CONJUGATED SYSTEMS

The consequences of steric interactions in organic molecules are of wide practical and theoretical interest to chemists, but the entire field of steric effects in organic chemistry is too vast to be covered in one conference. "Steric Effects in Conjugated Systems" was therefore chosen as the title for the Chemical Society symposium, held in Hull during July 15–17, because this topic is still of wide appeal to chemists and yet is sufficiently specialized to be treated in considerable detail by some fifteen papers, dealing with the study of steric effects by spectroscopic, kinetic, and other physical methods.

The introductory paper was read by Prof. E. E. Turner (Bedford College, London). He traced the chemical developments which led away from the Kaufler formula for diphenyl to the concept of a molecule comprised of two collinear benzene nuclei which will tend to be planar. This structure allowed an explanation of the optical isomerism of suitable diphenyls carrying four, three, two, or even one substituent in the sterically sensitive *ortho*-positions. This marked the discovery of molecular dissymmetry arising from restricted rotation about a bond—one of the most important steric effects which may arise in a conjugated system—and led to more recent work on 2 : 2′-bridged diphenyls. The conformational stabilities and molecular configurations for compounds containing two or more atoms in the bridge are now being studied by ultra-violet absorption spectroscopy.

Steric effects in diphenyl were also treated by Dr. G. H. Beaven (National Institute for Medical Research), who discussed the ultra-violet absorption spectra of pure alkyldiphenyls. While a 4-methyl substituent gives a red shift and an intensity increase of the conjugation band, 2-methyl substitution gives a blue shift and an intensity decrease. Further methyl substitution in the *ortho*-positions increases this effect, and the results are consistent with the hypothesis that progressive introduction of methyl groups into these positions gives progressive deviation from coplanarity and decrease in conjugation. Higher alkyl groups, unless branched, do not increase the steric effect, and the spectrum of 2 : 2′-dimethyldiphenyl suggests that the molecule has the *cis*-configuration already reported for 2 : 2′-dihalogenodiphenyls. The vapour-phase chromatography of these alkyldiphenyls was discussed by Dr. E. A. Johnson (National Institute for Medical Research), who has shown that the retention volumes for a single stationary phase depend on the position of the alkyl groups. Thus, 2-alkyldiphenyls have smaller retention volumes than the 3- or 4-isomers, presumably because the lower conjugation in the 2-isomer gives rise to less interaction with the stationary phase. The results confirm the conclusions reached from ultra-violet spectra relating conjugation to position and number of alkyl groups, and it has been possible to identify the peaks of a gas–liquid chromatogram of 21 isomeric tetramethyldiphenyls. Conjugation in 2 : 2′-bridged diphenyls and in halogenodiphenyls was also discussed in the light of the relative retention volumes for the compounds.

The influence of steric interactions upon the mesomorphic behaviour of 4-*p*-*n*-alkoxybenzylideneaminodiphenyls and 4 : 4′-di-(*p*-*n*-alkoxybenzylideneamino) diphenyls was discussed by Dr. G. W. Gray (University of Hull). A 2- or 2′-substituent in the diphenyl nucleus decreases the mesomorphic thermal stability more than a 3- or 3′-substituent. Clearly, twisting about the 1 : 1′-bond interferes with the molecular packing in the mesophases, and indeed increasing size of halogen increases the effect. A methyl group appears to have about the same steric effect as a chlorine, and 2 : 2′-disubstituted derivatives appear to adopt a *cis*-configuration. It is difficult to assess the configuration of the unsubstituted diphenyl ring system in the mesophases, but the results suggest that it may be planar.

Prof. C. A. Coulson (University of Oxford) described the use of molecular-orbital theory to explain the observed blue wave-length shifts in the ultra-violet spectra of diphenyls when the molecule is twisted about the 1 : 1′-bond. Reference was made to an alternative procedure developed by Longuet-Higgins and Murrell for such a system A–B (A and B may be groups such as phenyl, nitro-, etc.), and this was thought to be of promise for dealing with nitroanilines, where a full self-consistent-field molecular-orbital calculation would be complex. Relief of steric strain by displacement was then discussed by reference to the idealized case of a benzene ring folded through an angle about the 1 : 4-axis. The method of using mean resonance integrals was applied to this condition, which is similar to that occurring in the *paracyclo*phane series, and used to explain the observed bathochromic shifts in these compounds. The same method was used to deal with 3 : 4-benzphenanthrene which on 5- and 4′-methylation gives a progressive red shift which must be due to steric strain. The calculated effective resonance integrals for the mono- and di-methyl compounds agree excellently with those derived from spectra, and, moreover, the observed methyl affinities and the calculated free valences of the hydrocarbon agree well. The technique of using an average resonance integral is safest for such large polynuclear molecules where the strain is uniformly distributed throughout the molecule.

The contribution of Prof. M. J. S. Dewar (Queen Mary College, London) on the light absorption of cyanine dyes also concerned the direction of wave-length displacements arising from deviations from coplanarity. Hypsochromic displacements occur in the unsymmetrical cyanines, but the more unusual bathochromic shifts are observed in symmetrical cases. Prof. Dewar criticized explanations of these effects based on resonance theory, and applied molecular-orbital theory to the problem. While the strain of small distortions may be taken up by twisting about the central bonds in the dye, it is possible that large strains cause distortion of the whole molecule—buckling of rings—and this would lead to bathochromic shifts. Prof. Dewar considered that a more detailed treatment of this kind would be useful.

Steric effects in dyes again featured in the paper by Dr. C. C. Barker (University of Hull) on basic di- and tri-phenylmethane dyes. When the three main types of basic dye—Michler's hydrol blue, malachite green and crystal violet—are substituted, the molecular conformation and the electronic absorption spectra are usually modified, and Dr. Barker related the direction and extent of observed wave-length shifts to the steric and conjugative effects of the substituents. Alkyl derivatives of the three main types were fully discussed, and with malachite green the effects of numerous substituents in the phenyl ring were determined for comparison with the effects of substitution in the dimethylaminophenyl rings.

To the two classes of steric effect in ultra-violet absorption spectra proposed by Braude—steric interactions causing changes in (1) intensity only and (2) both wave-length and intensity—Prof. W. F. Forbes (Memorial University of Newfoundland) adds a third, covering steric interactions which so inhibit conjugation that the system absorbs as two entities. The mechanisms underlying the different types were discussed, although, in the absence of planar reference compounds, the identification of the type of effect may be difficult. Prof. Forbes illustrated the effect of both substituent size and nature of solvent upon the type of steric effect, and mentioned developments to which adoption of the classification may lead.

Dr. E. S. Waight (Imperial College of Science and Technology, London) concluded from measurements of the ultra-violet absorption spectra of conjugated carbonyl compounds at 20° and −196° that type I steric effects cannot be associated with transitions from non-planar ground-states to near planar excited states. From the infra-red and ultra-violet spectra of αβ-unsaturated carbonyl compounds, it is concluded that 2-methyl-1-acetyl*cyclo*hexane has an s-*cis*-structure, which is not planar. Using the ideas of Longuet-Higgins and Murrell on electronic transitions in the system C=C—C=O, it is thought that steric hindrance to planarity will produce Braude's type I effect when the transition is to an electron transfer state, and to a type II effect when the transition involves locally excited states.

Steric effects in monomethyl 1 : 2-benzanthracenes were discussed by Dr. G. Dallinga (Shell Laboratories, Amsterdam). The basicity constants and rates of H–D exchange for the twelve methyl isomers correspond strictly, but the observed basicities can be discussed in terms of the methyl group's inductive effect only when steric effects do not operate. Steric effects must therefore influence both the basicities and the rates of exchange for these isomers, and it is proposed that the structure for the transition state for the exchange resembles that of the conjugate acid. To explain the enhanced basicity of the 9-carbon atom, a steric repulsion is proposed between the hydrogens on the 9- and 1′-carbon atoms.

The influence of *ortho*-substituents upon the reactivities of groups in aromatic molecules has been extensively studied, since the Hammett equation is useful only in correlating reactivities in *meta*- or *para*-substituted systems, where there is no steric effect. Mr. A. C. Farthing and Mr. B. Nam (Imperial Chemical Industries, Ltd.) have derived a four-parameter, modified Hammett equation for *ortho*-substituted systems:

$$\Delta \log K = \sigma_S \rho_S + \sigma_E \rho_E$$

A graphical test ($\Delta \log K/\sigma_S$ against σ_E/σ_S) for forty-five reactions in the literature gives a correlation which is good enough to warrant statistical analysis and which suggests that the equation has some empirical validity.

In electrophilic aromatic substitution or side-chain reactions involving an electron-deficient centre, strong resonance interactions occur between the centre and the substituent. Such interactions are unimportant in the ionization of benzoic acids from which Hammett substituent constants are derived, and the constants cannot be used to treat the above reactions. Prof. H. C. Brown (Purdue University, Indiana) seeks to extend the Hammett treatment to these exceptional systems by obtaining substituent constants incorporating such resonance interactions from the rates of solvolysis of phenyldimethylcarbinyl chlorides. These electrophilic substituent constants have proved useful in quantitatively correlating directive effects in electrophilic aromatic substitution reactions, but a theoretical basis is required for the empirical correlations.

A review of steric effects in nucleophilic aromatic substitution by Prof. N. B. Chapman (University of Hull) covered both primary kinetic steric effects—steric retardation or acceleration of reactions—and secondary steric effects—steric inhibition of mesomerism. Examples of these effects, many from Prof. Chapman's work on nucleophilic aromatic substitution, were given. Although steric acceleration of a reaction is rarer than retardation, the effect is often large when it occurs, for example, in the Smiles rearrangement of 2-hydroxy-2′-nitrodiphenyl sulphone to 2-*o*-nitrophenoxybenzenesulphinic acid. The difficulties in reaching mechanistic interpretations of primary kinetic steric effects were discussed, and attention paid to the influence of the size of the attacking nucleophilic reagent.

Dr. B. M. Wepster (University of Delft) illustrated how the careful interpretation of electronic absorption spectra can lead to a better understanding of chemical data. Thus, the linear relationship between the conjugation band intensities in the ultra-violet spectra and the ΔpK_a values for the *p*-nitroanilines confirms that the inductive and mesomeric effects of the nitro-group operate almost equally in these molecules. The absorption spectra data for nuclear-alkylated anilines and N : N-dimethylanilines are used to interpret their relative base strengths, while a study of substitutional changes upon the relative base strengths of the nitrogens in 4-aminoazobenzene assists in interpreting the spectra of these compounds in acid solution. The negative inductive effect of the dimethylamino-group and the relative rate-constants for the alkaline deacylation of 4-nitro- and 2 : 6-dimethyl-4-nitro-acetanilide were also discussed.

Finally, Dr. J. W. Smith (Bedford College, London) discussed dipole moment evidence regarding steric effects in aromatic molecules. Factors which interfere with the coplanarity of a group with the aromatic ring diminish the mesomeric effect and are reflected in the dipole moment. Thus, in *ortho*-substituted nitrobenzenes and N : N-dimethylanilines, μ(obs.) is less than μ(calc.). In anilines, however, an *o*-methyl inhibits mesomerism slightly, while the slightly larger bromine does not. Yet, dipole moment evidence shows that bromine has the greater steric effect upon nitro-, formyl, and acetyl groups. It is inferred, therefore, that the characteristics of the group are important in determining repulsions, and that bromine may have a smaller effective radius with respect to approach by hydrogen than by oxygen, and that the reverse applies to the methyl group.

G. W. Gray

OVERSEAS INFORMATION SERVICES

Speaking in a debate on the Overseas Information Services in the House of Lords on July 9, Lord Adrian stressed the importance of medical and scientific contacts in Commonwealth relations. Fellowships for advanced study and research to able young men and women, if properly used, were the best kind of information service we could give, and Lord Adrian thought we could well spend much more than the present £1 million on such contacts. He referred in particular to the Commonwealth Fund Fellowships, to the British Council's scholarships for postgraduate study and those of the Nuffield and Leverhulme Foundations. Other tributes to the work of the British Council were paid by Viscount Massereene and Ferrard, who, in opening the debate, also referred particularly to the importance of telling the world of our scientific and industrial achievements, Lord Birdwood, Lord Ogmore and by the Earl of Home and the Earl of Gosforth, who spoke for the Government. The Earl of Home assured the House that the Government wishes to strengthen and render more efficient all the information services, and stressed the importance of concentrating expenditure where it was likely to be most effective. In a notable tribute to the British Council he referred to the expansion in the number of Commonwealth students in Britain from between 2,000 and 3,000 in 1946 to 35,000 in 1957, when 11,000 were at universities. He thought, however, that the independent committee of advisers suggested by Lord Birdwood was unlikely to add much to the knowledge of the chief information officers of the Overseas Departments ; but he agreed to discuss the proposal and also that of the Drogheda report for a permanent advisory committee with the Chancellor of the Duchy of Lancaster later.

Lord Croft raised the question of the export of British books, particularly scientific and technical text-books, which in countries like India, Pakistan, Burma and Ceylon had largely been displaced by United States text-books, partly in consequence of the aid and information programmes of the American Government. This situation seriously handicapped the sale of British products overseas, and because the distribution of British books and periodicals created a favourable climate for such sales he suggested the Government might, particularly in areas where competition is heaviest, give aid to all central libraries, university libraries and education centres abroad in the selection of British books on particular subjects. For this purpose an initial expenditure of £40,000 and an annual expenditure of £8,000 should service some 400 centres. He suggested also the organization of a limited number of exhibitions of books in areas not served by the British Council and the establishment of a Joint Standing Committee of the British Council and the Central Office of Information on one side, and a voluntary organization of the National Book League and the Publishers' Association on the other, to consider the whole problem. Lord Crook added that about 100,000 copies of books from the United States were being distributed at cut prices and that besides spending 5 million dollars on the translation, publication and distribution of books abroad, the United States, under a low-cost publication programme, had in 1957 launched 4·5 million copies of books in 185 editions and 21 languages. He also pointed out that although we invented the British Book Export Scheme, we did not use it, and because of the Treasury's attitude there were in consequence no schemes for dealing with the position in Pakistan, in Israel and in Turkey. Even with the help of the Colombo Plan many Pakistan universities and libraries were unable to obtain the British books they need, and their science faculties had lacked all specialist periodicals over the past ten years; there was an unsatisfied annual demand there for £50,000 worth of British books and £15,000 worth of periodicals. The Earl of Gosforth, in concluding the debate, made no specific comment on this situation, but promised that all suggestions made in the debate would be carefully considered.

HOSPITAL SERVICES IN GREAT BRITAIN

THE debate on the hospital services in Britain, in the House of Lords on July 2, opened by Lord Nathan, was noteworthy both for the review of the first ten years operation of the National Health Service and for the stress which was laid upon medical research by Lord Nathan himself and other speakers. Lord Nathan said that while there had been no increase in the number of teaching hospitals, the number of beds had increased from 26,000 to nearly 28,000, and in the non-teaching hospitals from 475,000 to 481,000; the bed-occupancy had remained at just over 80 per cent in the teaching hospitals and increased from 79 to 83 per cent in the non-teaching hospitals. The medical and dental staff over the whole country had increased by about 30 per cent, and in the teaching hospitals the number of nurses had increased by 20 per cent, but only by 10 per cent in the non-teaching hospitals, where the number of out-patients was now about 18·5 million a year, compared with 9·5 million in the teaching hospitals in 1956 (an increase of 2 million on 1949). Lord Nathan referred to the increase in voluntary service in the hospitals, to the increased space demanded by new developments in surgery and treatment and, finally, to the extreme importance of research, including the value of sending staff abroad to study methods used elsewhere. We could not expect to retain in our hospitals or in Britain men of the right quality unless we provided them not merely with adequate remuneration but, even more important, with the opportunities for developing their powers and their careers within their profession to the utmost. As regards costs, Lord Nathan said that the Guillebrand Committee found that capital expenditure in 1952–53 was only one-third what it had been in 1938–39, and he added that running costs for 1958–59 were estimated at just under £400 million, an increase of 4 per cent on 1957–58.

Other points emphasized in the debate were the shortage of accommodation for elderly persons, the vital importance in the teaching hospitals of the personal influence of the teacher on the student. Lord Evans stressed the dependence of the standard of of our teaching hospitals upon this personal contact between teacher and student. He also suggested that the hospitals should be encouraged to seek additional sources of finance. Lord Moran referred to the importance of the redistribution and the increase in number of consultants, so that there were now available in almost every part of the country first-rate specialists in every branch of medicine, and he supported Sir George Pickering's suggestion that every drug in the Pharmacopœia should be investigated to see when it is necessary as the only way to reduce the drug bill of £74 million a year. Lord Addison said a brake might be placed upon research generally in teaching hospital groups, because of the difficulty in handing over to the Exchequer vote methods resulting from research activities after they had taken their place in normal clinical procedure, and suggested that some more frequent method of assessing the stages to which research had developed might be advantageous. Reference was also made to the great advance in the treatment of mental diseases, but Lord Pakenham thought that an expenditure of only 2 per cent of its funds by the Medical Research Council on research into mental health was inadequate.

In his reply for the Government, Lord Strathclyde pointed out that, since the Guillebrand report, capital expenditure had considerably increased and was now about £23 million compared with £12 million in 1952–53. He states that the Government fully realized the importance of research, and said that it fully accepted the value of travelling scholarships and that hospital boards had been given very considerable discretion to grant study leave. In 1948–57, £18 million out of a capital expenditure of £70 million had been spent on mental hospitals, and the percentage had risen from 23·9 in 1948–56 to 32·7 in 1956–57. The Government was also fully alive to the potentialities in the application of work study.

TRANSPLANTATION OF THE FOREBRAIN REGION IN BIRD EMBRYOS BEFORE THE ESTABLISHMENT OF A CIRCULATION

Homoplastic Transplants

IN a recent publication one of us described a technique by which the forebrain region of chicken embryos at the stage of development prior to the establishment of a circulation can be transplanted to hosts of a corresponding stage[1]. Successful auto- and inter-breed homo-transplants have been obtained. Some of the grafted embryos, including the graft, continued to develop in a fairly normal way up to the time of hatching. Further work with the forebrain grafts showed that some of the grafted embryos are capable, with very little assistance, of freeing themselves from the shell, and living thereafter for considerable periods. So far, five such animals have been obtained. Of these, one was an autografted Rhode Island Red, three were homografted Rhode Island Reds and one was a Rhode Island Red on to which the forebrain of a Barred Rock Black embryo was grafted. The autografted chick was killed 77 hr. after hatching. One homografted chick died 30 hr., another 36 hr. and the third 55 days after

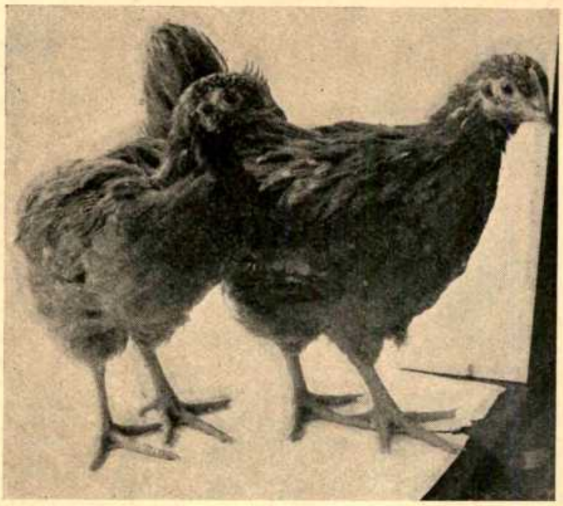

Fig. 1. Graft, Barred Rock Black; host, Rhode Island Red. Left, grafted bird; right, control. When photographed, this bird was 45 days old. The host is a female, the graft was probably taken from a male. Note deep toothed comb and absence of tail feathers

hatching. The Rhode Island Red to which the Barred Rock was homo-grafted is 60 days old and still alive; so far, its rate of growth has been nearly normal (Fig. 1).

One of the most frequently observed phenomena in such grafted chickens is a retardation in development, accompanied by lowered viability. In some embryonic chickens the incubation period was prolonged by 1–5 days; such birds failed to hatch. Anomalies in the appearance and in the distribution of pigment in inter-breed 'crosses' were also common.

In the chicks that hatched, retarded growth of the feathers and their anomalous distribution over certain regions of the body were also observed. In the two birds that survived for longer periods, especially in one of them, the rate of growth was less than that of normal controls. On the other hand, both of them had perfect control over their feeding reflexes; their movements were, or are, well coordinated, and the sight and hearing appeared to be perfectly normal. The functioning of the vocal organ was also normal. The autopsied embryos that have been examined so far had apparently normal pituitary glands. The hatched autografted chick was the only animal in which the pituitary gland was not found.

Crude operational technique may result in very imperfect healing between the two cut surfaces of the brain mass and, without unduly affecting the eyes and the mouth parts, give rise to profound disturbances in the anatomy of this organ. What type of healing is obtained with embryos that hatch, and how far the general state of the organism is affected by it, only further work will show.

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April 11.

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[1] Martinovitch, P. N., *Proc. U.S. Nat. Acad. Sci.*, **43**, No. 4 (1957).

Heteroplastic Transplants

BY the use of a technique originally applied to transplants of the forebrain region in chicken embryos[1], reciprocal transplants of the forebrain region between chicken and duck embryos were attempted. Figs. 1 and 2, of a chicken forebrain graft to a duck, and of a duck graft to a chicken, respectively, illustrate the possibilities of the growth and development of grafts between embryonic hosts belonging to two different species of birds. We have not, as yet, analysed closely the processes taking place in the course of development of these grafted embryos, but in their essentials they are similar to those observed in homografted ones. The establishment of vascular connexions between the host and the graft is somewhat delayed in comparison with that in homografted embryos and this may seriously affect further differentiation and growth both of the graft and the host. In spite of this, normal-looking eyes developed in both chicken-to-duck and duck-to-chicken grafts, and an almost normal upper beak in some chicken-to-duck transplants (Fig. 1). A fairly normal but retarded upper bill was formed in a duck-to-chicken transplant (Fig. 2).

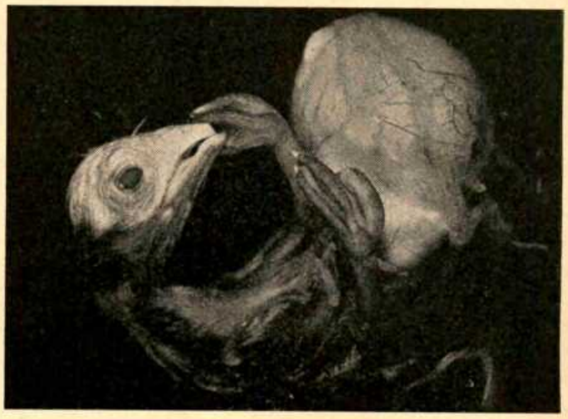

Fig. 1. Graft, Rhode Island Red; host, Khaki Campbell. Embryo removed from the shell on the 22nd day of incubation. The mandible has developed from the host tissues, and the upper beak from the graft

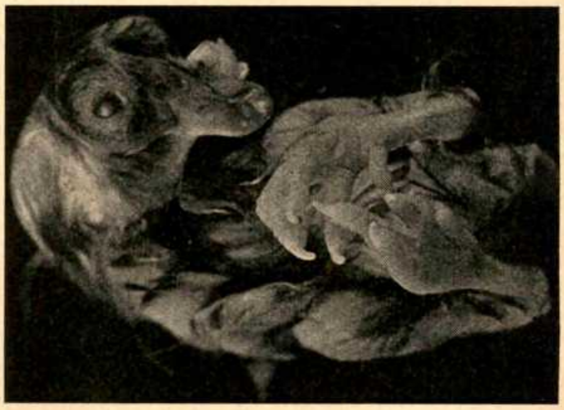

Fig. 2. Graft, Khaki Campbell; host, Rhode Island Red. Embryo removed from the shell after 23 days of incubation. The right eye and the upper bill are well developed; the left maxilla is defective

(*Continued on page* 589)

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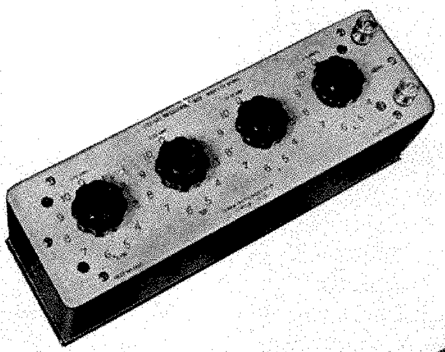

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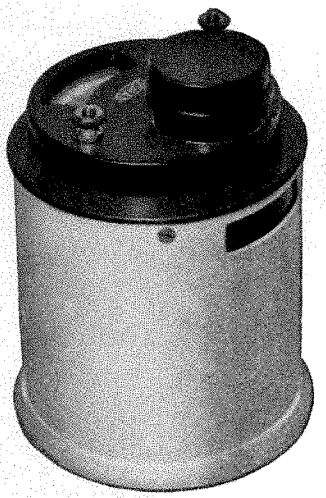

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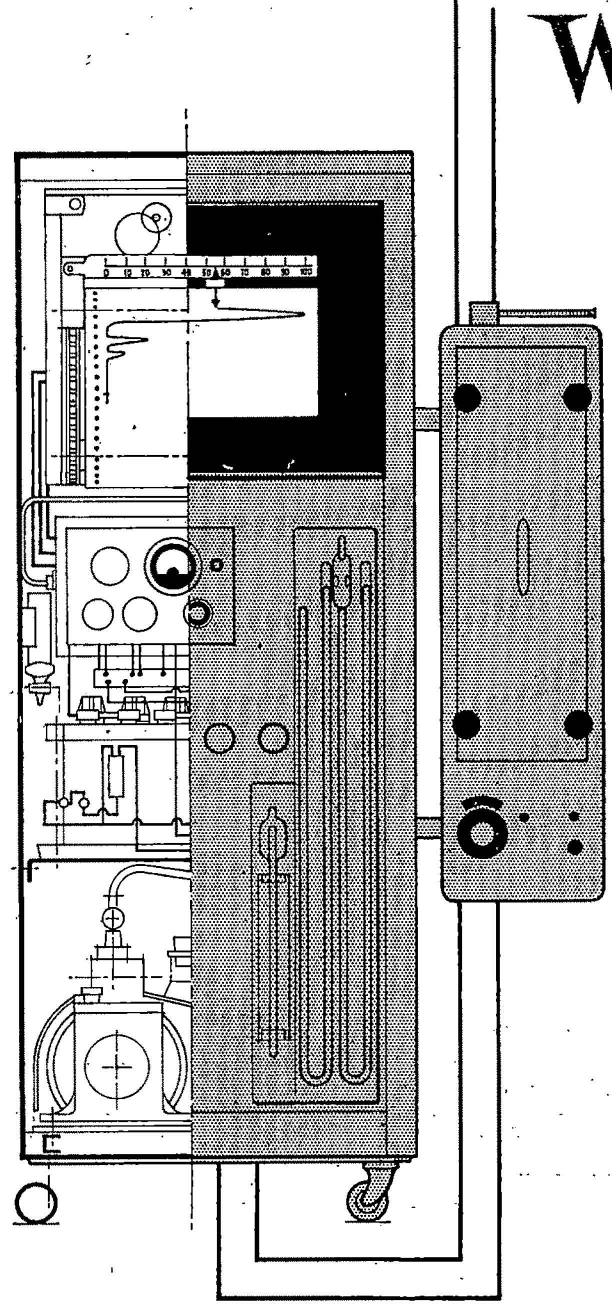

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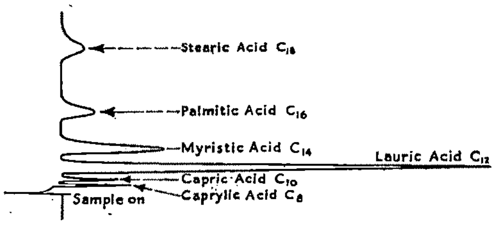

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BRITISH ASSOCIATION MEETING IN GLASGOW

SCIENCE AND BUSINESS: A BALANCED PARTNERSHIP*

By Sir ALEXANDER FLECK, K.B.E., F.R.S.
President of the British Association

THE British Association has returned to Glasgow after the passage of some thirty years. The president on that last occasion was Sir William Bragg, and it is good to know that his son maintains a fine scientific tradition as director of the Royal Institution and of the Davy Faraday Laboratory. We are glad to have this opportunity in the course of our scientific deliberations to see something of the progress that has taken place in Glasgow and its region since then. In 1928 the Scottish Lowlands were reasonably prosperous : they had not yet entered the lean and hungry years of industrial depression when men's labours ground to a standstill and unemployment paralysed much initiative. As is well known, the depression lasted until early 1939, to be followed by the trials of war, death and destruction from the air, and all the while the deluding sense of prosperity that war brings. Since the end of the War, Glasgow has seen great industrial activity, though there are again threatening clouds in the sky.

But Glasgow's story goes back far beyond the fluctuating fortunes of the past thirty years. The little Cathedral town which emerged from the sixth century settlement beside the Molendinar has become one of the greatest cities of the Commonwealth. The shallow, unpolluted Clyde has become the deep-dredged channel which has carried the world's largest ships, a source of trade and prosperity to Scotland.

We of the British Association pay tribute to the creative scientific thought of the citizens of Glasgow which has enriched the world : first, Adam Smith, original economic thinker, who stood between the two storms that broke over Scotland—the Reformation and the Industrial Revolution ; then the chemist, Joseph Black, whose work on the theory of heat helped to inspire James Watt, himself prime mover of the Industrial Revolution. Lister, a past president of the Association, came to revolutionize surgical methods ; Kelvin, another president, established principles of thermodynamics and electricity, and so 'put a girdle round about the earth'. In our own time, Soddy's work on atoms helped to name the new atomic age, presently so much in our minds.

These are some of the men who towered above their contemporaries and their century, men whose names make the British Association proud to renew its contact with the City of Glasgow and recall the debt that the world owes to it.

We hope that the citizens of Glasgow will always, in the same inspiring tradition, promote the advancement of science, technology and philosophical thought.

I am very sensible of the honour that the Council of the British Association has done me by electing me president for this Glasgow meeting and so enabling me to come back with the Association to the place in which I first saw the light of day just on the south bank of the Clyde. The surroundings there were all of trade and business, so I trust I can with appropriateness express some general thoughts on business and science and the need for a proper balance between them. This subject is very different from those chosen by most of the presidents who have addressed this Association in the 127 years of its existence : they have spoken from the wealth of their expert knowledge of some science to which they have added great lustre. There is no science with which I, on the other hand, can claim the intimate acquaintance of a practising scientist. It is many years since I worked at a laboratory bench and experienced the excitement of anticipation all research workers feel as a well-planned experiment approaches its conclusion. That phase passed into one in which I supervised and directed others to do such work, and later that also was left behind under the pressures of full-time administration. The result of all this is that I am no specialist in any branch of science. Rather, I approach my task here as a sort of common man of science, who, lacking the detailed knowledge of the specialist, has at least an understanding of the framework within which scientific thought evolves.

All the same, it may be felt that in my dual capacity as president of the Association and as an administrator, I run the risk of finding myself a business man among scientists and a scientist, even if only a lapsed scientist, among businessmen. Perhaps I may remind you of a remark ascribed to Talleyrand : "War is much too serious a thing to be left to military men". I have the impression that the same sentiment may apply both to the conduct of business and to the advancement of science. The risk of being neither pre-eminently scientist nor pre-eminently businessman may be counterbalanced by advantages that come from a non-specialist approach to science and business. I hope to show why such an approach may be particularly appropriate to the needs of the moment.

Science

In a population which depends so much on science, it is sad to think how few people clearly understand what it is all about. It is an approach to an understanding of the universe along a broad highway of organized knowledge firmly founded on observation and experiment embedded in a matrix of theory. It is a highway which is constantly being widened and extended and repaired. We are building it because we think that, by and large, it is a good road for mankind to travel, and that it is leading him away from ignorance and wretchedness towards a fuller life and a better world. Some find that the act of extending the highway gives them all they seek from their life-work: these are the pure scientists, and much of our progress derives from them. Others find greater satisfaction in utilizing what has already been built, pausing perhaps to strengthen it here, widen it there: these are the technologists, or applied scientists. A few people combine both functions, driving the road forward into undiscovered territory, then paving it ready for all to use. Whatever our own work may be, we have a joint responsibility to see that the highway is properly and extensively used by all mankind. It is therefore fitting that the British Association is now devoting itself to the additional task of securing the greater use of this highway by all types of people in these islands, more especially as we enter what is often called the Second Industrial Revolution.

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* Presidential address delivered in Glasgow on August 27 and appearing in the September issue of *The Advancement of Science.*

In the First Industrial Revolution man learnt to convert chemical energy, derived from the reaction between carbon and oxygen, not merely into heat but also into mechanical energy, steam being the key to the process. In the Second Industrial Revolution we are turning from the external properties of carbon atoms to the internal properties of the lightest and heaviest atoms in Nature as a source of energy to expend as prodigally as we like, thus husbanding carbon atoms as a source of materials.

Another feature of the Second Industrial Revolution is the growing interdependence of the sciences as they advance on a broad front. To review the achievements of the past year or two alone, the launching of the Russian and American Earth satellites depended on prior developments in several different sciences and technologies. Chemical rocket fuels, refractory combustion chambers, and radio transmitters which dispatched back to the Earth information of great relevance to the theme of the International Geophysical Year, all played their part. Miniature transmitters themselves followed the invention in the Bell Telephone Laboratories ten years ago of the transistor, which in turn owes its successful development, at least in part, to the perfection of methods for separating traces of boron and other elements from silicon to a degree of purity exceeding one part in a thousand million.

All of us here recognize the creative possibilities of thermonuclear fusion energy opened up by the Harwell and Aldermaston experiments on high-temperature electric discharges. Although most of the neutrons so far produced have not originated from thermonuclear fusion, there can be no doubt that ZETA and SCEPTRE are symbols of man's reach into a future of boundless energy; his grasp of such a prize could well rank as his greatest material achievement in the history of the world. In such experiments as these, as indeed with the discovery of nobelium, a pre-requisite of success is a flourishing electrical industry which can provide many of the tools of nuclear physicists.

Scientific effort on this scale costs money; indeed, the total annual research expenditure in Great Britain alone is estimated to be £300 million. Such effort also costs scientists. Public expenditure on education (including the universities) in Britain is now some £740 million a year; if our universities are to grow large enough to accommodate everyone who could benefit by such an education, instead of merely the 3½ per cent of the population who enjoy it now, then we shall need to contemplate spending something nearer £1,200 million a year. These are large sums, and if, as a nation, we are to stay solvent they can only come from one source, the wealth which we produce.

Business

In this context it is easy to see the importance and responsibility of business, which produces and distributes most of our national wealth. Our capacity to extend our science and education largely depends on our ability to run business successfully. Lewis Mumford in his "Technics and Civilization", written in the 1930's, though he appears to exaggerate their numerical importance, suggests that it may have been no accident that there were merchants of the City of London who played a part in the early days of the Royal Society. He directs attention to the affinity of science and business when he writes: "The power that was science and the power that was money were, in final analysis, the same kind of power: the power of abstraction, measurement, quantification".

On an occasion such as this it is difficult to avoid being at once too general and too particular. I have chosen to speak of business because business is a more comprehensive term than industry. At the same time I intend to limit my scope primarily to the larger units, although naturally I recognize the importance of the smaller organizations—indeed, in manufacturing industry alone, three-quarters of all establishments employ fewer than a hundred people.

Defining the limits of my subject in this somewhat arbitrary way will, for the moment, do service for a formal definition of the term 'business'. After all, it is a vague word, perhaps for euphemistic reasons in the past even deliberately vague. Nevertheless, I venture to put forward three characteristics which I think a business should have if it is to survive and function effectively over a period of years.

(*a*) First, it must contribute to the well-being of the community and its social evolution. I believe it can best do that in three specific ways: by producing goods or services for the community at fair prices; by giving fair treatment in the way of remuneration and working conditions to all who give their services to the business, whether as payroll employees, administrators or scientific staff; and by giving a fair return to those who risk their money in the business, so that, apart from this consideration, they will be encouraged to provide again for further ventures. When business takes on itself the deployment of financial, material and human resources, it also takes on, I believe, the responsibility for seeing that they are properly and effectively used. In other words, it has an obligation to the community; and only in so far as it fulfils that obligation does it contribute to the well-being of the community and justify its own existence.

(*b*) Second, business must have the capacity to change its methods and if necessary even its objectives. It must be constantly alert to see that its products or services meet or anticipate the needs of the public, and to withstand the nipping and eager air of competition whether it comes from advancing techniques or from new entrants into the field.

(c) Finally, if it is to be self-perpetuating through growth or modernization, a business must dispose of its products or services for more than their cost—or in plain language, it must make a profit. That is true of business whether run by private enterprise or by the State ; nor does the political system of the State make any difference to the validity of this notion. Only from the excess of income over expenditure can we finance the expansion of business and science.

This brings me again to the reason why I have chosen to talk about business rather than industry. It is an old saying that money makes money ; by the same token the production of wealth requires the investment of wealth, and such investment can come from a variety of sources. Traditionally, part comes from retained profits, that is from what economists in the past called the abstinence of the individual manufacturer, or in to-day's terms, from the undistributed earnings which companies plough back into the business. Part comes from the banks, though their function in Britain has usually been to provide working capital in the form of loans and overdrafts, rather than to provide fixed capital like the industrial banks of Germany, which played such a prominent part in the organization and growth of industry in that country. Indeed, we can share Disraeli's suprise that the London money market played such a small part in the financing of the railways. In "Endymion", published in 1880, he wrote : "What is remarkable in this vast movement is that the great leaders of the financial world took no part in it . . . even Lombard Street which never was more wanted, was inactive, and it was only by the irresistible pressure of circumstances that a banking firm, which had an extensive country connexion, was ultimately forced to take the leading part that was required". To-day by far the largest volume of capital comes from the investing public as private individuals or financial institutions, working with a vigorous and well-informed Stock Exchange.

There is, of course, no exact relationship between the amount of income which a country ploughs back into capital formation and the rate of economic growth which it achieves. Nevertheless, I think that certain generalizations can be offered. For example, we can compare the experience of the United States with that of Great Britain. Between 1870 and the First World War, the United States devoted more than one-fifth of its national product to home investment, and the United Kingdom only about one-tenth. During that period its national product grew by more than 4 per cent per annum compared with less than 2½ per cent in Britain. More recent history, in spite of occasional and, one hopes, temporary setbacks here, suggests the same lesson : over the past forty years, the United States has invested about half as much again in relation to its resources as we have, and its national product has risen at an average rate of about 3 per cent per annum, against only about 2 per cent in the United Kingdom.

I do not wish to strike a note of disappointment so much as to recall the classic virtues of abstinence, saving and investment. In fact, during the past ten years the amount which the United Kingdom has invested in its productive resources has shown an encouraging growth, with the apparent result that output in manufacturing industry, as a whole, has increased by some 3½ per cent per annum since 1948, compared with about 2½ per cent between the two World Wars. If science has laid the foundation for much of this expansion, business has provided the will and the means to complete the structure, and both must continue to do so.

There is another reason why it is important that this partnership should continue to flourish. We have in the British Isles more than 50 million people who enjoy a material standard of living surpassed in few other countries in the world. Our mineral resources are limited and indeed declining. It is by means of the goods produced by manufacturing industry and the services provided by finance and commerce, in short by business as a whole, that our 50 millions are enabled to live, and on the whole to live tolerably well, in an area too small to feed them, at least by present methods.

All this is commonplace, but like much that is commonplace, it is easily taken for granted until we remember that more than 90 per cent of the world's population live in countries less prosperous than our own, most of them in conditions that we should not dream of tolerating. The world does not owe us a living ; we can only enjoy the standards which our business enterprise and scientific knowledge enable us to earn through our exports. Like all countries depending on their export trade for a livelihood, we in Britain have a vested interest in economically and politically stable conditions throughout the world—and I mean stable, not static, conditions. Stability will not be achieved, for example, if plans for industrialization of the less-developed territories are obstructed from a misconceived notion that we may thereby be able to retain our own markets for that much longer. To those who heard Prof. P. M. S. Blackett's plea last year for technological aid to the under-developed countries, this may sound an unnecessarily narrow approach. But I have deliberately couched my argument in terms of expediency rather than moral compulsion, because it emphasizes one respect in which the combination of science and business seems to me to be vital, and it is this : we must concentrate for our own survival on the development of new products and new processes.

Our old staple exports of textiles, iron and steel, and coal have long since given way to newer lines—vehicles, aircraft, machinery, chemicals and electrical goods. Even here the pattern keeps changing. Motor vehicles, fine and heavy chemicals and so on, are increasingly being manufactured in countries which previously produced only food or primary raw materials. In India, I am told, a company manufacturing diesel engines and electric motors is exporting 30 per cent of its output. Chemicals from Red China and mass-produced toys and torches from Hong Kong are met in many of the world's markets. We are therefore obliged to rely either on selling things which no one else has yet learnt to make, or make as cheaply, or on marketing our skill and 'know-how'.

It is not difficult to find examples of what happens to our business when 'rule of thumbism' is preferred to operations guided and controlled by science and technology. I think there would be general agreement that at various times some of our traditional industries in which we were pioneers have suffered from the lack of proper scientific direction.

In my own industry, organic chemicals once experienced the same neglect. The lead that Perkin had given to our synthetic dyestuffs industry with mauveine was frittered away through lack of scientific effort. In the presidential address to the Chemical Society in 1915 his son, William Henry Perkin Junior, referred to this neglect in these words :

"My experience of the manufacturer in this country is that he is usually merely a commercial person who does not like the expert, and especially the idea of giving the expert a prominent position in the control of his works. Possibly the reason in many cases is ignorance of the value of science, but more probably it is due to the fact that being ignorant of science himself, he feels that if the expert is given too much prominence he must either study himself in order to understand the expert or leave the essential control of the business in his hands. Both these courses are distasteful to the ordinary commercial member of a board of directors; the expert is therefore relegated to the background, and the business comes to grief".

The lesson has not yet been fully learned, for even to-day we meet this attitude. I have a quotation here from a managing director who went on record last May. The scope of his company may be small and may be provincial, but that the sentiment still exists in minds capable of directorial control is significant. He writes: "The place of the expert is not in the saddle but as the assistant and the adviser. The scientist must be on tap, not on top". Such a relationship is very different from the partnership of science and business that I have in mind.

I have considered briefly some reasons why I regard the partnership of science and business as fundamental. To recapitulate, first it is because, if science is to carry forward our social evolution, it needs the financial and productive effort of business; and second, because the prosperity of Great Britain depends on the technologically sophisticated products of our export trade.

A Balanced Partnership: How to Achieve it

(*a*) *The scientist in the business structure.* I should now like to examine how this partnership can be achieved in practice, by considering the place of the scientist in the business structure. In a technological business we can distinguish some six or seven separate functions, depending to some extent on their definition: finance, commerce, personnel, operation or production, design and construction, research and development. I propose not to elaborate on these functions fully, but to touch on one or two of their features.

First, research: research has been called the lifeblood of industry, but I prefer to liken it to the pituitary gland which, I am told, after doing little that is obvious for several years except consume nourishment, at length stimulates other parts of the organism to develop and makes it capable of production.

Research applied to business can take different forms, and one example within my experience may be given. It began with a research manager's conviction that a new inhalant anæsthetic was needed which should have the following properties: it should be a volatile liquid, with high anæsthetic potency, and be free from toxic, explosive and fire hazards. These criteria, he argued, pointed the way to aliphatic halogen compounds containing little hydrogen and especially to compounds with two or three fluorine atoms on the same carbon atom—groupings which are known by organic chemists to be not only unreactive in themselves, but also to strengthen neighbouring carbon-halogen bonds. The resulting inertness is one of the factors in avoiding toxicity; and the use of fluorine rather than other halogens keeps the volatility high. He also proposed a new method of expressing dosages which made it possible to relate, by using a principle of chemical thermodynamics, the amount of anæsthetic in the inspired air to that in the body fluids. This helped in the selection, for biological testing, of compounds likely to have the desired potency, among which the one finally chosen was 2-bromo-2-chloro-1 : 1 : 1-trifluoroethane, a new compound synthesized especially for the purpose.

The major research effort, which for the first two years fell to the organic and physical chemists, had at this stage passed to the pharmacologists, whose screening tests took some three years. They showed that the new compound had not only the properties sought, including a high margin of safety from overdose, but also some unexpected advantages. Clinical trials with successful results began six years after the research started, and meanwhile manufacturing methods were developed by chemists and engineers, leading to general release to the medical profession two years later.

There are several features about this much abbreviated story, some of which are relevant to my present theme. It illustrates, first of all, the systematic application of pure scientific principles to a desired and well-defined end which, though primarily commercial, is not without social implications. Second, the research threw light on the physico-chemical basis of anæsthesia, which time, if no other reason, forbids me to enlarge upon. Third, success was crucially dependent on the existence of a team of specialists in several scientific disciplines and also in the somewhat recondite technology of fluorine; notwithstanding these favourable circumstances and adequate financial backing, the research and development took seven years. Fourth, the distinction between the research and the development function of business is brought out: the original synthetic and early testing work was research, while the development consisted of devising suitable methods of manufacturing and launching the chosen compound, and of studying its clinical effect.

I now turn to the functions of design and construction, which are essentially the field of the technologist or engineer. His grasp of scientific principles, combined with the creative skill of a Telford or a Fowler, fits him above all to build a bridge between science and business. It has been said: "The establishment of the class of engineers . . . is the more important because this class will, without doubt, constitute the direct and necessary instrument of coalition between men of science and industrialists, by which alone the new social order can commence". These words of Auguste Comte remain as fresh and as true to-day as when they were written more than a hundred and thirty years ago.

The production or operation function includes the application of technical methods often according to a routine, though it also demands much planning and organization. Although such work is sometimes considered humdrum and repetitive compared with research and development, it is often essential for it to be done by highly qualified technical men. It is just as great a mistake to believe that unqualified men who come up what used to be called 'the hard way' are generally adequate, let alone best, for production work, as to hold that good technical people are wasted in such jobs as plant management. On the contrary, they must be encouraged to regard it as an interesting and necessary part of their training for higher management.

If there are to be no weaknesses in any one part of the organization, technical staff may have to be moved from one department to another, and this places a vital responsibility on those exercising the personnel function in selection, training and promotion; at the same time it is their duty to ensure that employees can find satisfaction in their work. This function also can be conveniently performed by a scientist, whose knowledge of what the technical departments require helps him to place staff to the best advantage, both of the business and themselves.

On the commercial side also, scientists may be needed in sales, sales service or purchasing, to achieve the best results for a business making technically complex products. I cannot agree that employment of technical men in commercial departments is necessarily wasteful: it gives flexibility within the business, and can often ensure smoother co-operation when a works manager or research chemist feels that his own—the technical—point of view is understood by a man in one of the commercial departments; moreover, as training for higher administrative posts, commercial experience is invaluable to the scientist.

When he reaches such a post, the scientist, recognizing the value of science in business administration, will be well placed to exploit it. I am not thinking here only of new equipment in the office, such as electronic computers or apparatus for sensing letters and figures; science has more to offer than mere tools. It offers the whole philosophy of the scientific approach to the problems of management. I need only mention some of the steps involved: definition of the problem, observation and collation of the relevant facts, formulation of a hypothesis or principle. its testing and its general application.

This approach has been of untold value in the examination of human activity and its measurement, which is usually described as work-study. It has also been very successfully employed in the problems of supply and distribution, in adjustments of stock-levels and in planning of delivery programmes. The full application of such methods usually involves some specialist techniques, especially of a mathematical kind; but even the first qualitative steps of the scientific approach can often lead directly to improvements in business efficiency. All the same, it is worth noting that an otherwise successful application of such techniques can founder on the inability to handle human relationships with proper understanding.

Finance has played a conspicuous part in my address and, in my experience, no technological business ever attempts to progress without continually seeking financial advice. However, I have failed to see in Great Britain an equal acknowledgment that financial institutions need to take the benefit of continuing technological advice, though I am glad that some progress is being made in this direction overseas. For example, I know of a bank specially interested in natural resources which employs full-time geologists. Again, the World Bank Organization in Washington employs technical men not only at headquarters but also to carry out specific missions in various countries. Finance and technology will, I hope, become more and more interdependent as our businesses adapt themselves to current needs.

There is scope then for the scientist to infiltrate throughout almost the whole business structure. That being so, it is pertinent to ask, if scientists are to play an important part in business administration, is the balance between science and business likely to be upset? The answer to this question is, I think threefold.

First, as British industry is at present constituted, the balance is heavily tilted the other way. That is to say, there are still many enterprises which are not employing qualified technical men even in tasks where one would expect to find them, and conversely there are no industries that appear to be harmfully dominated by scientists. This is due partly to the shortage of scientists and technologists with which we are all familiar, but partly also to historical circumstances. In the nineteenth century, due to Britain's wealth of practical engineering experience, theoretical knowledge was under-valued. At the same time, an educational bias towards the classics, based on an aristocratic tradition, sometimes led the second and third generation of a manufacturer's family to forsake the business altogether for politics or the Bar, or if not, at least to be quite unfamiliar with the value of science. Again, as we have seen, in some concerns scientists are relegated to the position of advisers to management and are allowed little part in the active control of the business.

Second, in businesses where scientists rightly play a prominent part in administration, non-technical men who nevertheless have a good understanding of scientific principles are with advantage sometimes put into semi-technical jobs, and this helps to maintain a balanced partnership.

Third, and most important, the balance that we seek must come in great measure from within the individual himself, a balance provided by the education which the scientist and the non-scientist ought to receive. This, besides being central to my theme, is very much the personal concern of many of us here.

(*b*) *Balance in education.* There are three senses in which we might consider balance in education. The first arises from two different conceptions of the purpose of education. On one hand there is the formation of character and the development of intellect and personality. At the other extreme is the concept which I suppose finds its most powerful expression in the educational philosophy of Soviet Russia, that the purpose of education is to provide useful members of society in which the desires of the individual must be subordinated to the needs of society.

I do not believe that these two concepts are wholly conflicting or that the second runs completely counter to the British tradition of individual liberty. A balanced educational system should have room for both. The striking successes achieved by the Russians in science and technology are directly attributable to a system of education deliberately designed to produce large numbers of technically trained men and women with the ability to increase the economic power of the country through industrialization. To this end they established a strong teaching profession to which recruitment is no problem, because it enjoys the highest pay and status of all the professions. Though undoubtedly State direction still has a place in the Russian educational system, its purpose is being achieved to an increasing extent by incentives.

We are proud that the universities of the United Kingdom, despite their growing financial dependence on the State, still retain their academic independence intact. Nevertheless, they have quite properly reacted to the stimulus of the country's needs which have led the older universities, for so long the home of the humanities, themselves to enlarge their science faculties. The new St. Catherine's College at Oxford and Churchill College at Cambridge will give particular prominence to the study of science. The introduction of transfer scholarships to enable promising arts men to turn to science has been readily accepted. More sixth-formers are reading science in the public and grammar schools. Some long-term financial incentives may operate here, but more important has been an intensive propaganda effort which, I hope, will be sustained by the British Association's programme for organizing lectures up and down the country on the lines of those so successfully pioneered by the Royal Institution in London.

So, in framing our formal education, we cannot entirely ignore the requirements of the society on the prosperity of which depend the very conditions in which our educational system can progress; but our society will not be tolerable to live in if its members are not permitted to develop their personalities and talents.

This brings me to the second sense in which I refer to balance in education. I am thinking here of the need for those who study the humanities to have some understanding of the workings of science, and for our scientists to widen their horizons by relating their science to its human context both historically and in terms of the present day. I have in the past on several occasions declared my belief that the gulf which at present separates our scientists and non-scientists is much more easily bridged than is often imagined. For example, the qualities of mind which are fostered by studying chemistry and history are very much alike. Both chemists and historians must cultivate an inquisitive and acquisitive mind. Both need to exercise judgment, leavened with a good measure of scepticism in the exemplary tradition of Robert Boyle. Both must be imaginative, the chemist in advancing hypotheses to predict the future, the historian in doing so to explain the past.

The merits of a balanced curriculum are recognized in Soviet Russia, where children between eleven and seventeen devote something like 46 per cent of their working hours to science subjects, with the emphasis predominantly on mathematics, and another 46 per cent to what we would call arts subjects, with the emphasis here on Russian language and literature. Clearly a correct balance can never be achieved with premature specialization, which the current demands for entry into many universities impose on our most talented students.

There is a third and final sense in which I refer to balance in education. I have said that we demand, from our scientists and non-scientists alike, intellectual qualities, such as curiosity, judgment and imagination. Equally we want our young people, whatever their branch of study, to possess high qualities of character. I need not enlarge on this theme except to say that the society which a balanced partnership of science and business can help to build will as always call for courage, integrity and tenacity. These are some of the ideals that we might have in our minds as we each address ourselves to the problems of education for an age of science.

My theme has been broad and general. It does not call for revolutionary action; it calls rather for sustained progress, and, of the two, that is sometimes the harder to inspire.

In education, Glasgow has an enviable reputation. I have already referred to some of the famous names connected with the University. Alongside its fine academic tradition, we can rejoice in more than 150 years growth of higher technical education. The Royal College of Science and Technology, as its name has been since 1956, can trace its origins back both to Birkbeck's Mechanics' Institution and also to Anderson's College, founded in 1796, where Birkbeck himself taught.

Where such institutions exist to teach and practise science, and where there is still the business acumen and mercantile tradition of the Glasgow 'Tobacco Lords', I hope my plea for extending the partnership between business and science will fall on fruitful ground. In Glasgow, so long ago as 1799, Tennant exploited the discovery of chlorine to found a large chemical business. Again, in this City was discovered the cyanide process for separating gold from its ores, a process which has enabled gold to this day to be mined on a scale massive enough for it to be still a measure of world finance and commerce. Symington's *Charlotte Dundas* and Bell's *Comet* were forerunners in the technology of power-driven ships such as have made the Clyde shipbuilder's skill famous throughout the world. Kelvin's fundamental work on electricity and his maritime interests led him to found a business based soundly on practical physics.

I have tried to show why science and business must be partners: the advancement of science can only be achieved with the resources which business can provide and, if business is to provide them, then it must bring science to its aid. I have also suggested that a truly balanced partnership will manifest itself in the growing use of science and its methods in business; and that it can only come from a balanced education for scientists and businessmen alike.

I believe this balance to be important for our well-being, and as we inaugurate this 120th meeting of the British Association, we can take with sincerity and all humility for our own work, the objective for his college expressed in Anderson's will:

"For the good of Mankind and the Improvement of Science".

SUMMARIES OF ADDRESSES OF PRESIDENTS OF SECTIONS

SOME ASPECTS OF THERMONUCLEAR RESEARCH

DR. T. E. ALLIBONE discusses in his presidential address to Section A (Mathematics and Physics) some aspects of thermonuclear research.

If the fusion of deuterium ions is to yield a useful amount of energy, the temperature of the gas must be maintained in excess of 100 million degrees, and it therefore follows that the hot gas must not be in contact with the walls of the vessel containing it. A large current passed through the gas will heat it ohmically and the magnetic force associated with the current will constrict the discharge and draw it away from the walls, thereby compressing it and thus augmenting its temperature. Many investigators have pursued this line of research; British investigators have mainly used toroidal discharge tubes in which a pinched ring discharge is created by electromagnetic induction, whereas American and Russian investigators have used straight discharge tubes, thereby choosing to ignore, for the time being, end losses at the electrodes.

Very large electric currents lasting for short times were readily produced in the straight tubes and bursts of neutrons were detected several years ago. The fact that the bursts of neutrons lasted for only a few tenths of a microsecond and occurred only two or three times throughout a 10-microsecond current pulse was surprising; moreover, the rate of release of neutrons was far higher than could be accounted for. It did not rise appreciably as the discharge currents were increased, and it diminished rapidly if impurities were present. Further study revealed the fact that the discharge developed instabilities in a few microseconds, and at localized constrictions of the discharge, ions were given energies far higher than their mean energy. It was the collisions of these locally accelerated ions which produced the fusion reaction yielding the observed neutrons.

The toroidal discharges studied in the Atomic Energy Research Establishment at Harwell and at the Research Laboratory of Associated Electrical Industries, Ltd., at Aldermaston were maintained for times of the order of a millisecond, during which other forms of instability developed. To a certain degree it was found that these instabilities could be reduced by the application of a steady magnetic field parallel to the discharge path. As the discharge is constricted in the presence of this axial field, currents circulate around the cross-section of the discharge, thus enhancing the field within the discharge and reducing the field outside it. It was found that with optimum values of applied axial magnetic fields the toroidal discharges yielded neutrons over a large fraction of the total duration of the current pulse, both in the apparatus ZETA at Harwell and in SCEPTRE at Aldermaston. Moreover, measurement of the Doppler broadening of some of the spectral lines of impurity elements in the gas indicated ion temperatures corresponding to several million degrees, at which true thermonuclear fusion should yield neutrons comparable in number with the observed neutron flux.

In recent months it has been proved that neutrons and protons released in the fusion reaction in the same direction as the ions in the discharge have energies a little higher than those emitted in the opposite direction; the difference is due to the forward velocity of the deuterium ions at the moment of fusion. This velocity has been found to be appreciably in excess of the mean velocity of deuterium at the temperature estimated spectroscopically. It may be that the spectroscopic measurement is in error, for the discharge, though reasonably stable, can be seen to be moving about rapidly within a confined volume on the axis of the torus, and some of the Doppler broadening may be due to lateral velocity of the beam. To resolve some of the anomalies and uncertainties, ZETA and SCEPTRE are being modified to operate at higher temperatures.

Some of the other ways of attaining high gas temperatures appear to be very promising. Following disclosure of the Russian linear pinch discharge, the Atomic Weapons Research Establishment, Aldermaston, has developed an even faster linear pinch which has produced neutrons; preliminary indications are that these do not arise from instabilities of the discharge. The most recent American and Russian work will be discussed in Geneva on September 4 and may not be commented upon at this moment. Several novel methods of containment of a plasma have been described in recent American literature, but the Russians have disclosed nothing since 1956.

THE CHEMISTRY OF THE TRANSURANIC ELEMENTS

PROF. H. J. EMELÉUS, in his presidential address to Section B (Chemistry), states that it was a natural result of Fermi's observation of the n,γ reaction, whereby an element such as gold could absorb a neutron and by subsequent β-decay be converted into a mercury isotope

$$\left({}^{197}_{79}\mathrm{Au} \xrightarrow{n,\,\gamma} {}^{198}_{79}\mathrm{Au} \xrightarrow{\beta} {}^{198}_{80}\mathrm{Hg}\right)$$

that similar experiments should be done with uranium in the hope of making isotopes of a then unknown element 93. Irradiation of natural uranium actually gave both fission of uranium-235 and neutron-capture by uranium-238. From this confused start, however, clear-cut methods for producing the transuranic elements have now emerged. These are, in brief: (1) bombardment with artificially accelerated particles; (2) neutron bombardment; (3) multiple neutron capture; (4) bombardment with heavy ions. By using these methods, physicists and chemists jointly have now produced ten new elements ranging from neptunium ($Z = 93$) to nobelium ($Z = 102$).

In considering the chemistry of these elements, much attention has been given to the place which they occupy in the Periodic Table, and it now seems certain that they constitute a new group analogous in electronic structure to the rare earth elements. This implies that the 5*f*-electron shell is progressively filled. It would have its maximum complement of fourteen electrons in the hitherto undiscovered element of atomic number 103. This electron assignment is based, first, on the analysis of the emission spectra of some of the elements in question. Secondly, the magnetic properties are analogous to those of the rare earth elements. Thirdly, crystal structure determination of many solid compounds of the new elements have enabled values of ionic radii to be assigned. These show a decrease as the series is ascended, which parallels closely the well-known lanthanide contraction in the rare earth series. Absorption spectra of the transuranic elements also show characteristic sharp absorption bands, associated with transitions within the shielded 5*f*-level.

Chemically, the new elements differ from the rare earths in that, instead of having predominantly a valency of three, higher values are found. This is associated with the great ease with which the electrons are lost.

The maximum valency of 6 is most stable in uranium, but it is also observed in neptunium, plutonium and americium. Curium and berkelium, the next two elements, have valencies of 4, but, so far as is known, the higher members of the series are restricted to a valency of 3. Of the chemical techniques which have been applied in this work two may be mentioned specially. The first is solvent extraction, which is widely used in laboratory work and also plays an important part in the technical separation of plutonium from uranium and fission products. The second technique is ion exchange. The chemistry of the new elements is, for the most part, studied with minute amounts of material far below the limits that could be weighed with a chemical balance. Here the classical techniques of tracer chemistry have been revived and developed. It is the use of tracer technique which has shown that the higher members of the series are restricted to a valency of 3.

The discovery of so many new elements in the past twenty years naturally leads to speculation as to where this process will end. Present indications are that there are very few others which will be stable enough to survive. Stability is limited both by radioactive decay and by spontaneous fission. Nevertheless, a careful search is at present being conducted to extend the field. This work offers an unusual challenge not only because there is such a large unexplored region but also because it calls for very precise and painstaking research.

BENEATH THE EARTH'S CRUST

PLANS recently made to drill a borehole some ten kilometres deep, which may provide information about the Earth's mantle, prompted Prof. L. R. Wager, in his presidential address to Section C (Geology), to review existing ideas on the material of the mantle and to consider the implications if it proves to be similar to the alpine type of peridotites.

Current geophysical evidence suggests a model of the Earth in which the relatively light crust, of variable composition and thickness, rests on the far more uniform and dense mantle at depths of about 10 km. under the oceans and 20–50 km. beneath the continents. The mantle is characterized by a velocity of propagation of compressional waves of about 8 km./sec. and a density of 3·3. It is thought that the sub-crustal material is in a crystalline rather than liquid state down to 2,900 km., beyond which is the apparently very dense liquid core, presumed to have a nickel–iron composition. The facts of isostasy show, however, that, despite the solid condition of the mantle, it must be capable of flowing under sustained stress.

Of the known igneous rocks those with the closest approach to the observed physical properties of the mantle are the peridotites and related olivine-rich types. Some peridotites (for example, those of Sgurr Dubh in Skye) are the result of accumulations of olivine crystals from large masses of associated gabbros and may be described as autochthonous cumulites. Others, however (the alpine type), are common in fold mountains or island arcs, and are not associated with gabbros; these are considered to be possible samples of the upper mantle. It can be shown that basaltic magma could be produced by partial melting of peridotite; a peridotite mantle might therefore explain the world-wide distribution of basaltic rocks.

It is possible to postulate a mechanism for the formation of the Earth's silicate shell based on analogy with layered intrusions. The Earth is considered to have passed through a liquid stage. Convection currents due to cooling from the outer surface would establish a thermal gradient less than the gradient of elevation of melting point due to pressure. Consequently, crystallization of high-temperature minerals might be expected to occur from the bottom upwards. As the column of accumulating minerals increased in thickness, its weight would eventually lead to the expulsion of liquid in the pores, consisting of the components of lower melting point, from the lower parts.

The nature of the crystal phases earliest to separate is uncertain. But by the time the accumulation had reached about 200 km. from the surface the liquid was probably close to forsteritic olivine in composition, and olivine, enstatite and chrome spinel would be the primary minerals precipitated. Later, plagioclase and augite would be expected to form, and finally, when crystal accumulation had reached to within about 10 km. of the surface, a residual liquid of granodioritic composition would be expected, which further cooling would form into the crust. During this long process, convective action must have been modified partly by the heating effects of the radioactive constituents of the fluid expelled from the mush and partly by the changing mechanical properties of the solidifying mantle. In particular, convection currents would be very restricted in the later stages, when the crust had solidified. Perhaps a major convective overturn in the mantle at an intermediate stage, before final solidification of the crust, was responsible for pushing the sialic scum into the restricted areas now occupied by the continents.

SOME BIOLOGICAL EFFECTS OF LOW TEMPERATURES

THE presidential address by Dr. A. S. Parkes to Section D (Zoology) discusses the biological effects of cold. This subject has attracted many of those prominent in the history of science, including Robert Boyle, Réaumur and Spallanzani. These early workers relied on natural conditions or simple freezing mixtures to obtain their effects, but they contrived to experiment with a wide variety of living cells and organisms. During the past century, the availability of solidified carbon dioxide and the liquid gases has enormously increased the range of temperatures over which experiments can be conducted, and naturally the range of experimental material has also been increased. At the outset we can distinguish two main branches of the subject: first, the study of the effect of cold on the whole organism, whether it be an insect or a man; and secondly, the study of the effect of cold on the isolated cells or tissues, or even whole organs of an organism. From our present point of view, what is important is the internal temperature of the cell, tissue or organism, the environmental temperature being of importance only in so far as it influences the internal temperature.

Cold-blooded animals allow their body temperature, within certain limits, to fluctuate in keeping with environmental temperature. Some of the lower cold-blooded animals, notably insects, have a remarkable tolerance for cold, not merely in the range of temperatures above zero but actually in a range well below zero. This tolerance appears to depend partly on a striking capacity for becoming supercooled and, in some instances, on the ability to withstand the crystallization of the body-water as ice. This tolerance of sub-zero body-temperature under natural conditions is not seen in the higher poikilotherms, and stories of fish and frogs frozen solid in blocks of ice are almost certainly apocryphal.

In contrast to cold-blooded animals, warm-blooded animals maintain a closely controlled body-temperature which is almost always between 37° C. and 41° C., and which in most parts of the world is much above environmental temperature. Some warm-blooded animals, however, hibernate during the winter, and in this state they take on many of the characteristics of cold-blooded animals. Non-hibernating warm-blooded animals were commonly supposed to die if body temperature was artificially reduced to a level at which heart-beat and respiration ceased. It is now known, however, that under laboratory conditions a warm-blooded animal such as a rat or a hamster can be resuscitated from deep body temperatures below zero. As the body-temperature goes below zero the animal either supercools or begins to freeze. The former process is comparatively benign; the latter has so far proved lethal when pushed to a stage at which more than 50 per cent of the body-water is converted to ice.

It is more easy to generalize about isolated cells and tissues. Among the invertebrates, certain cells survive being subjected to extreme cold, but almost all the normal cells and tissues of vertebrates are killed by freezing and thawing under ordinary conditions, and little progress was made in this field until it was discovered that certain substances, notably glycerol, protect cells and tissues against the otherwise fatal effects of freezing and thawing. By the use of glycerol it has been possible to freeze certain types of mammalian cells and tissues, especially spermatozoa, red blood cells, and endocrine tissues, and keep them at low or very low temperatures for long periods, and afterwards to thaw them out and use them effectively for insemination, transfusion or transplantation. It may be that further refinements of technique will make it possible to dry these cells from the frozen state and permit long-term storage at ordinary temperatures.

The study of the biological potentialities of low temperatures is at present one of the growing points of biology, and it is likely to contribute substantially to man's powers over Nature.

THE ATLANTIC ENDS OF EUROPE

THE presidential address by Prof. E. E. Evans to Section E (Geography) presents some results of researches into the origins of human settlement and the development of land use and social systems in the Atlantic fringe of Europe, with special reference to Highland Britain and Ireland. The environment of the Atlantic Ends is characterized by deeply indented coasts backed by infertile massifs of ancient rocks relieved by scattered patches of recent glacial or fluvial deposits. Climatically, the mild winters, heavy all-season precipitation and high values of wind and cloud have favoured pastoralism rather than arable farming. Consciousness of an Atlantic culture-area extending from Galicia to Norway was strongest in the early days of Christianity, by which time fishing and seafaring, extensive stock-rearing and restricted arable farming were well adapted to the three major elements of the environment. Independence, pride of blood and strong personal loyalties were characteristic features of society. The prevailing form of settlement was the joint farm or extended-family holding, a cluster of peasant homesteads possessing common rights in infield, outfield and mountain grazing. These house-clusters must be distinguished from the villages of the European plain, and it is suggested that they are a type of prehistoric settlement which persisted in the far west. Further, the Atlantic long houses, only one room wide, are similar in plan to those of neolithic Europe. It is argued that the system of co-operating kin-groups was maintained along the Atlantic in environments which called for common effort yet could be utilized without the technological equipment and complex organization of a manorial system. Early Indo-European institutions, reaching the west probably during the late Bronze Age, were absorbed and became fossilized.

Already in the third millennium B.C., shifting cultivators of the western Neolithic had reached the Atlantic Ends and tapped the fertility of forest soils with crops of wheat and barley. During the early Metal Age, when supplies of tin, copper and gold became commercial assets, the fringe experienced a golden age. In the sub-Boreal, dramatic environmental deterioration affected upland areas, where bogs replaced forest, following clearance by man and podsolization. The megalithic cult had been widely adopted and the great stone monuments, the abodes of powerful ancestral spirits, became symbols of a lost fertility.

After the introduction of oats and other innovations in the Early Iron Age, a readjustment allowed a second blossoming-period in the sixth to ninth centuries, and a third phase of expanding food resources and population followed the coming of the potato. With the enclosure movement and the scattering of farms, commercial agriculture came to be based on the old outfield practice of 'taking the plough round the farm' by using long leys.

Within the British Isles, the Atlantic inheritance had made a distinctive contribution to British life, and to overseas lands through heavy emigration, and Prof. Evans makes a plea for the preservation of regional variety in a world weighted in favour of uniformity. There is a danger that movements towards the restoration of self-government will lead to isolation. Along the Atlantic shores, peasant attitudes of immemorial antiquity have not entirely succumbed to the impact of a money economy. Idealization of the past and a reverence for spiritual values, coupled with suspicion of impersonal external authority, have sprung from the experience of living in the Atlantic Ends.

BRITISH ECONOMY UNDER INFLATION

PROF. A. J. BROWN, in his presidential address to Section F (Economics), states that the outstanding feature of the British economy since the War has been the low level of unemployment in comparison with both pre-war experience and the most sanguine war-time expectations. This low level appears to be explained in part by an alteration in the behaviour of employers. It is noteworthy that variations since the War have been mostly in hours of work or, secondarily, in the number of people available for employment, whereas before the War they took place mainly in the proportion of the labour force unemployed.

The great cause of high and steady employment since the War has, of course, been freedom from fluctuations in demand. Most of all, we have been remarkably free from any major fluctuations in world demand for our goods and services. There has, however, been a very marked fluctuation in internal demand for inventories, which may be a new phenomenon in Britain, though it is well known in the United States, and which might have been expected to produce marked fluctuations in employment such as have occurred in America.

The main reason why Britain has escaped these fluctuations in employment is that variation in demand for inventories has been largely taken up by variation in imports, but the method of financing government expenditure has helped somewhat and there has been fortuitous assistance from variations in defence expenditure and also from variations in the prices of our imports.

The question arises whether the high level of employment has diminished the adaptability of the economy. A simple measurement of the amount of change in the British economic structure in the years 1948–56 shows it, in fact, to have been almost identical with that experienced in the years 1929–37 (the amount of change in the intervening period 1937–48 having been about twice as great). It is natural to inquire further whether this adaptation to economic forces since the War has taken place by a different market mechanism from that of the 1930's. It proves to be the case that, on the whole, the industries which expanded relatively to the rest in the 1930's were not those in which earnings rose most. On the other hand, there is a definite tendency for the industries which have expanded most since 1948 to have obtained their increased share of the labour force by raising their earnings in relation to others.

The record of progress in Britain in regard to the standard of living since the War has been good by previous standards but not striking in comparison with other countries. It is very difficult to find any close connexion between this progress and the timing of new investment; in fact, in manufacturing industries especially, the striking feature of the past ten years has been the increase of output in relation to both labour and capital.

The amount of saving (and hence of investment) in the economy does not seem to have been adversely affected to any marked degree by post-war inflation. Such reduction as there has been in it after allowance is made for the level of disposable real income does not seem too great to be accounted for largely by change in distribution of income. A further indication that our inflationary experience is not likely seriously to have affected saving is that there is little sign in the prices of assets or in the level of interest-rate in relation to money holdings that steady expectations of rise in prices have had much influence. It may be concluded that Britain's record of high employment and economic progress since the War has been reasonably satisfactory in many ways, but that a considerable part of our success is due to external circumstances which may change and with which we may not have adequately equipped ourselves to deal.

HEAT AND THE ENGINEER

PROF. O. A. SAUNDERS, in his presidential address to Section G (Engineering), comments that in pursuing his art the engineer must always encounter many problems of heat and heat transfer. These occur in the generation of power from heat, in the control of heat-influenced processes, and in many problems of engineering design where the production of heat is a nuisance. In the field of power generation, interest is increasing in the direct conversion of heat into electricity by some form of thermionic converter which would allow the elimination of expensive turbo-alternator machinery, and would have many applications for small generating sets even though the thermal efficiency were not high. The possibility of direct conversion of nuclear energy into electricity, although remote at present, would have far-reaching effects on power stations of the future.

The engineer is vitally interested in progress of the fundamental science of heat transfer, which has advanced greatly during recent years. By the use of numerical methods and computing machines, it is now possible to solve many problems theoretically, and the field of laminar flow convection is now well covered. For turbulent flows, however, where the greatest practical interest lies, empirical methods are still needed, although the understanding of these flows has improved. The gas-cooled nuclear power reactor has posed some interesting problems of turbulent-flow heat-transfer, and their solution is of great practical importance.

The regenerator is an attractive principle of heat exchange, and new ideas for rotary regenerators have come forward in recent years; but it is difficult to design a satisfactory mechanical arrangement, especially for the moving seal between the two fluids. The prospects of the gas turbine for automobiles and other mobile applications would be transformed if a reliable and efficient regenerator could be developed.

The problems of aerodynamic heating have been increasingly felt in high-speed aircraft and missile design, and novel means of overcoming them have been put forward, including sublimation of the surface layer of the material in the case of missiles and the use of cold fuels such as liquid hydrogen for supersonic aircraft. There are many other interesting new lines of research and development in industrial heat transfer. The dropwise condensation of vapours, which would give a useful reduction in size of power station steam condensers, has been successfully promoted chemically for copper-alloy tubes, but for stainless steel surfaces such as are used in condensing organic vapours it has not so far been possible to find a promoter which will adhere satisfactorily. The control of radiation from luminous furnace flames has been improved by research on large-scale furnaces, and, for example, the use of pitch creosote to control and improve the relation from non-luminous coke over gas flame has been successfully worked out.

In electrical engineering, the use of hydrogen, especially at elevated pressure, for cooling turbo-alternators, has been the biggest factor in improving the performance of machines and has made possible the increase of the output of the single unit from 200 to 350 megawatts. Liquid metals as heat carriers have received special attention from the nuclear reactor designers because of the favourable neutron-capture properties of sodium and potassium and their alloys and because of their high rates of heat transfer. It is likely that these metals will find new uses outside the nuclear field now that handling problems are being overcome.

Creative research, inventive development, inspired design and novel construction in the field of heat transfer are all needed to keep pace with the needs of modern technology.

THE STUDY OF FOLK LIFE AND ITS PART IN THE DEFENCE OF CIVILIZATION

IN his presidential address to Section H (Anthropology and Archæology), Dr. Iorwerth C. Peate points out that anthropology—the science of man—is a vast field of which folk life, like archæology, is a small corner. The change of the title of Section H in 1947 from "Anthropology" to "Anthropology and Archæology" is to be deprecated, since anthropology is a large enough umbrella for us all. The student of folk life is concerned with the study of every stratum in the community, and with all communities except those completely affected by a high degree of industrialization.

Folk life as a field of research has developed from the study of collections of 'bygones' in museums, and it is therefore often believed, erroneously, that it is concerned only with the post-medieval period. There is no date-line at which the study begins. Nor can it be said to end with the Industrial Revolution, for even in communities affected in part by industrialization, much evidence remains of the persistence of traditional ways of life. The traditional cultural pattern, from its early beginnings to the present day, is the basis of study.

Pioneer work in the Scandinavian countries, particularly the work of Dr. Sigurd Erixon, the late Åke Campbell and the late Wilhelm von Sydow, established the standard by which most work on the subject must be judged. Certain aspects of the study may be mentioned. (*a*) The study of houses. Most major works on English architecture are of little use in the study of folk life, for they ignore the smaller buildings such as farmhouse and cottage. Regional studies such as Fox and Raglan's "Monmouthshire Houses" are urgently needed before any interpretative work can be carried out. (*b*) Similar records are required for problems such as transhumance. (*c*) The student of folk life should be chary of accepting uncritically such theories as those of a time-lag in fashion in areas far removed from a metropolis or of national forms of costume—theories which are based on insufficient evidence and basically unsound.

The study of folk life cannot be confined merely to visual materials. Speech and local dialects are an important part of it: vocabularies of the hearth and home, those relating to domestic animals, agriculture, festivals, religion and all social activities. The work on oral traditions carried out in England, Scotland and Wales should, Dr. Peate believes, be financed by the State. The refusal by the State to give an emergency grant to record the traditions of North and South Uist is thoroughly to be deplored.

We study the eternal task of 'building up a civilization in Nature' in all the little nations of Europe. Their traditions are the buffer between the passive barbarism of the West and the active barbarism of Eastern Europe, between two world forces which threaten to reduce the world to the level of brute sensation. The study of folk life has, therefore, a purpose beyond the mere limits of an academic discipline: not only does it contribute to the sum of scientific knowledge but also it assists in the rehabilitation of a degraded civilization.

SOME ASPECTS OF CELLULAR DIFFERENTIATION

DR. E. N. WILLMER, president of Section I (Physiology), comments that the manner in which the cells of a highly developed organism such as man differentiate is not a problem which can ever be solved by the study of that organism alone. For example, in human embryology there comes a time when certain connective tissue cells, the fibroblasts, begin to produce collagen and form an inter-cellular fibrous matrix. The problem of the formation of these fibres was not, however, first solved for man; its solution must have already been achieved many millions of years ago when the calcareous sponges were first evolved, for they, like the majority of animals in all groups, form a ground-substance with collagen fibres.

It may therefore be more profitable to investigate the collagen-forming cells when they first appear, as, for example, in sponge embryos, than to study them only in what may be a specialized form in man. In the embryos of calcareous sponges, the fibre-forming cells originate from the flagellated cells which constitute the animal pole of the embryo. The posterior amœboid cells do not apparently contribute. An investigation of the difference between these two types of cell may therefore yield information about the original conditions which led to the production of fibres. At an even more primitive level, study of an amœba (*Naegleria*), which shows dimorphism, in that it may exist in either an amœboid or a flagellate form according to the ionic concentration of its surroundings, emphasizes the influence of the ionic environment on cell form. It perhaps also suggests the possibility that the anterior and flagellate cells of the sponge may react in one way to their ionic environment while the posterior amœboid cells react in an opposite manner, and that the two types of cells are combined in one embryo in such a way as to maintain the ionic stability of the organism as a whole.

The further possibility that, since the fibre-forming cells of the sponge are formed from the flagellate cells of the embryo, the mucoproteins and fibres (or their precursors) are in some way related to the maintenance of ionic equilibrium by the cells seems to be one worth considering. The suggestion is therefore made that the preservation of ionic equilibrium by a cell may involve the production of certain metabolic by-products; for example, hexosamines or related substances from which mucoproteins and mucopolysaccharides can be built on one hand, and glutamic acid, proline, or hydroxyproline from which collagen fibres can be synthesized on the other. A cell which is moving cations across its membrane in one direction may perhaps drive these by-products in the other direction. Some cells derived from the flagellate cells (for example, fibroblasts) would thus be in a strong position for forming intercellular matrices, because they normally liberate the necessary precursors, whereas other cells, for example, those corresponding to the amœboid cells, would be more likely to store the mucoproteins within their cytoplasm and have to turn the glutamic acid, proline, etc., to other uses within the cell.

This is certainly an over-simplification of the position, but it may serve to illustrate a general principle. It may therefore be more profitable to tackle cellular differentiation from rather more basic premises, and to study the origin of the simplest colonial forms, for it was they who were the first to solve the problems of cell adhesion, of ionic and osmotic balance, and of mechanical stability. If it could be discovered how they achieved these ends, and how their cells became differentiated accordingly, then the mutual relationships of cells, in higher organisms, and the influence of hormones and 'organizers' upon them, might be made somewhat more easily intelligible.

SOME PROBLEMS OF COLOUR VISION AND COLOUR BLINDNESS

THE presidential address to Section J (Psychology), by Prof. R. W. Pickford, marks the jubilee of psychological studies in Glasgow, for the lectureship in general and experimental psychology in the University of Glasgow was established by the University Court in 1907, and H. J. Watt, the first lecturer, began his duties in 1908. The Laboratory of Experimental Psychology was established in part with a donation in 1908, and a gift of auditory apparatus from his collection, by friends of Prof. John G. McKendrick, formerly professor of physiology in the University of Glasgow.

The history of colour blindness tests has shown a number of interesting developments, from the use of coloured wools by Holmgren, to Edridge-Green's lantern, beads and spectrometer, and other and better lantern tests have been devised, notably by Giles. The most popular tests of colour blindness have been pseudo-isochromatic charts and tables, such as the Stilling, Ishihara and other tests. Farnsworth's and Dimmick's tests are great improvements upon them.

The Rayleigh equation of a mixture of lithium red and thallium green, matched against a standard of sodium yellow, has led to the Nagel anomaloscope, which uses spectral lights, and to several other kinds of anomaloscope, which are mostly filter instruments. Similar equations, especially of blue and yellow, or of blue and green, have been utilized as tests for blue and yellow vision.

The results of anomaloscope tests show an instructive grouping of colour-vision defects and variations, depending on combinations of variability of matching range, deviation of mid-matching point and shortening of the red or violet end of the spectrum. There are two main types of red–green blindness: (1) protan defects, including protanomaly, extreme protanomaly and dichromatic protanopia; (2) deutan defects, including deuteranomaly, extreme deuteranomaly and dichromatic deuteranopia. In addition, there are tritanopic defects, or yellow–blue blindness, and minor forms of variation along the lines of the protan, deutan and tritan defects. Total colour blindness should also be mentioned.

Red–green blindness is a sex-linked Mendelian recessive character, found in about 7·5 per cent of men in Britain. It shows interesting variations of frequency in different geographical areas and racial groups, the lowest percentage reported among men being 0·5 per cent in Fiji by Geddes, and the highest probably being 12·8 per cent among Toda men by Rivers. Co-ordination of testing standards is not easy. Yellow–blue minor defects are more frequent among dark-skinned peoples, but red–green defects are less frequent among them than among whites.

It is generally agreed now that there must be two series of major red–green defective genes, with separate loci on the X-chromosome, and about three alternative forms in each series, in accordance with the classification given above. A woman may inherit two types of defective gene, one from each parent and from different series, and yet have apparently normal colour vision. In certain cases of sex reversal, as in Klinefelter's and Turner's syndromes, in which the individual has developed sex organs contrary to the 'genetic sex', the frequency and pattern of inheritance of colour blindness is that expected for the 'genetic sex' rather than for the masculine or feminine phenotypes. For example, in an interesting pedigree there is a male 'woman' of the type found in Turner's syndrome, who must have inherited her colour blindness from her mother, for her father has normal colour vision. Colour blindness is an incomplete recessive, since women heterozygous for it show minor defects more frequently than normal homozygous women.

Colour blindness requires three general hypotheses to explain its nature and variations: (1) the 'loss' hypothesis, which assumes the absence of certain functions or sensory end-organs; (2) the 'collapse' hypothesis, which assumes the failure of certain functions to differentiate groups of light waves normally distinguished; and (3) the 'swing' hypothesis, which assumes variations in the distribution of sensitivities which may otherwise be normal. It seems that protanopia is a loss defect, deuteranopia is a collapse defect and that the various types of anomalous colour vision are due to swing defects either alone or in combination with one, or both, of the others. The whole subject is extremely complex.

The most favoured theory of colour vision is still the trichromatic theory due to Young and Helmholtz, but there have been many advocates of others, notably polychromatic theories and the four-colour theory due to Hering. At present, it seems that the trichromatic theory would be adequate to account for all forms and variations of colour vision and its defects, provided that we are allowed to introduce the concept of swing defects.

The studies of colour vision defects and of tests for their detection and measurement are of the greatest importance, especially where life and safety depend on the use of colour signals, and also in those industries in which fine colour discrimination and judgment are required.

THE CAPE AS AN ANCIENT AFRICAN FLORA

THE presidential address to Section K (Botany) by Prof. R. S. Adamson points out that the so-called Cape flora is a very distinctive one in Africa which has its main development in a small area in the extreme south-west of the continent. The flora is a very rich one with a high proportion of endemics, and is made up of portions with different geographical relationships.

Though this flora in its typical form is confined to the south-west corner, there are distinct traces of it in other regions, notably on the higher mountains throughout the continent, and also to a lesser extent in the Mediterranean flora of the north coast of Africa. The floras of the adjacent islands, Madagascar and the Atlantic Islands also show clear affinities. All appear as old floras and floras with a common origin.

Though the Cape region is the largest and much the richest of the portions existing, it is not suggested that it was the source from which the others arose. Instead, the portions are regarded as being remnants of the area of a once widespread flora that covered the more temperate parts of the continent. Changes of climate and of geography have resulted in the disappearance of the flora in the intervening areas. The original flora must have existed at a time when islands such as Madagascar were united to the mainland.

The existing parts have undergone development and change since their establishment, especially in the Cape region, where the area is largest and conditions have remained favourable.

In attempting to trace the possible origin of this old flora, its close relationships with those existing in south and south-west Australia and in the south-west of South America are noted. The most probable explanation is found in the theory of continental drift. The old flora was one that became established when there were land connexions. Those existing to-day are the descendants of the separated parts, each of which has become modified by local developments and by immigration from adjacent regions.

THE PARTNERSHIP BETWEEN INDUSTRY AND EDUCATION

SIR WILLIS JACKSON says in his presidential address to Section L (Education) that he would like to interpret his selection as president of the Section as a recognition of the importance which is attached to the place of industry in the educational structure of Britain. It affords him the opportunity of paying tribute to the considerable educational service which is being performed by many industrial concerns, and to the part they have played towards establishing within the schools a belief that industry can offer to those with a sense of vocation as satisfying a career as the 'learned' professions which have traditionally attracted a dominant proportion of our most able young people. The increasing number now devoting themselves to a prolonged study of science and technology means more than a mere recognition of the material importance of scientific and technological achievement, and more than a growing acceptance that scientific subjects, properly taught, are no more specialized than, and provide as good a vehicle of education as, arts subjects. It means that industry is coming to be seen not merely in terms of machines and technical processes but also of men of character and stature; and that it provides great opportunities not only for the exercise of scientific and technological skill but also for co-operation in service and in human relations.

Sir Willis Jackson also makes forthright comment on the fact that the contribution of very many other firms towards the further education and the practical training of their juvenile recruits is much less than is demanded both by their own best interests and by the well-being of the country as a whole. He refers to the increase since the War in the willingness of industry to release its young employees to attend day-time technical courses, but also to the wide discrepancies which exist between different branches of industry and to the enormous scope for further improvement. His main anxiety, however, concerns the dearth of satisfactory facilities for apprentice training at all levels, which, unless corrected as a matter of urgency, is likely to frustrate the developments now taking place within the schools, technical colleges and universities of Britain, and to produce a serious national situation when much increased numbers of young people become available for employment in the early 1960's. After outlining the comprehensive training schemes organized by some large industrial concerns, he advocates a considerable expansion of co-operative arrangements among groups of small and medium-sized firms. In his opinion, however, these will develop too slowly if left to the initiative of industry alone, and that in any event the time has come when the national interest requires independent assessment of the adequacy and effectiveness of present-day concepts of apprentice training. So far as graduate and student apprentices are concerned, there are at least signs of machinery, within some of the professional institutions and within the National Council for Technological Awards, by which advice may be given and appropriate pressures may be applied. But even these do not exist in respect of the nationally no less important spheres of technician and craft training. He compares the caution of the recent Carr Committee report on "Training for Skill" with the forthright recommendation in the 1944 report of a conference of representatives nominated by the Manchester and

District Committees of the Engineering and Allied Employers National Federation, the Amalgamated Engineering Union, the major engineering institutions and the Regional Advisory Council for Technical and other Forms of Further Education, that a National Apprentice Council and associated regional councils should be established, and that their directing activities should be supported by a national fund provided jointly by the State, the local education authorities, and the employers and trade unions concerned.

After referring to the serious shortage of science and technical teachers, Sir Willis says that the more effectively industry fulfils its responsibilities in the fields of education and training the fuller will be the benefit which will accrue to it—employer and employee alike—and through it to the nation.

DIGESTION IN THE RUMINANT

IN his presidential address to Section M (Agriculture) Dr. D. P. Cuthbertson points out that the outstanding difference between the ruminant and other herbivores is that the former pre-ferment their food through microbial action in the first two compartments of the complex stomach—the reticulo-rumen sac—before digestion by enzymes secreted by the digestive glands begins in the abomasum or fourth stomach. Considerable absorption of the soluble products of microbial activity takes place from this sac. In the third compartment, the omasum, absorption of water is the main feature.

The reticulo-rumen sac thus forms a fermentation vat in which bacteria and protozoa are established under highly reducing conditions when the animal is quite young. Fermentation of cellulose through microbial activity takes place there; otherwise it would be unavailable through lack of a cellulase in the digestive glands. In grass itself, and especially in root crops, other fermentable carbohydrates exceed cellulose in amount and being more soluble and less resistant structurally and mechanically than cellulose, are more readily fermentable by a much wider variety of micro-organisms, but not necessarily to the same ratio of desired products.

The reticulo-rumen sac is never empty, and constitutes a functional field in which all the activities are organized for utilization of microbial products and all factors therein make for a steady state. The activity of the salivary glands, the process of rumination involving re-mastication, the absorption of the products of microbial activity and the interchange of ions between rumen contents and blood—in the case of sodium against the concentration gradient—all contribute to the continuity of microbial action during the whole life of the animal, and produce conditions which one can scarcely hope to reproduce *in vitro*. Nevertheless, by observation of the micro-organisms—the bacteria and the protozoa—at the site of their attack on food particles, and in isolation in culture, and by a study of the soluble products of fermentation and their absorption, much information about this microcosm has been obtained.

Consideration is also given by Dr. Cuthbertson to the early development of the ruminant: to the role of the saliva, and to the passage of food through the alimentary tract.

In the rumen, dietary protein is subjected to fairly vigorous hydrolytic conditions, and the low-molecular products, including amino-acids, are then assimilated by micro-organisms and incorporated into their body protein or, if amino-acids accumulate in excessive amounts, the micro-organisms acquire the power to ferment them deaminatively to ammonia, short-chain fatty acids and carbon dioxide. Further, it is known that urea and ammonia can also be utilized by the micro-organisms for elaboration of their own body proteins. These proteins are of good biological value and are presumed to be digested in the abomasum and small intestine in similar fashion to that taking place in the non-ruminant.

When cellulose and starch are broken down by the micro-organisms to soluble sugars, these, like other soluble sugars in the diet, are fermented to give short-chain fatty acids. These acids, together with those derived from protein, are absorbed from the rumen into the blood stream. It has been calculated that for hay-fed sheep, about 70 per cent of the total energy requirements is provided by these fatty acids. These short-chain acids are quantitatively much more important than glucose as a source of energy.

While the microbiological synthesis of fat-soluble vitamins (other than vitamin K) has not yet been unequivocally demonstrated, the metabolic needs for the various B vitamins are met by synthesis in the reticulo-rumen through microbial activity. The synthesis of vitamin B_{12} is conditioned by the cobalt content of the feed. Ascorbic acid appears to be synthesized in the ruminant's own tissues.

This pre-gastric microbial digestion confers important benefits upon the ruminant. Energy from fibrous foods, which could not otherwise be obtained, is more efficiently garnered and the available energy is yielded over a longer period of time, so that the animal is more resistant to periods of starvation; the uptake of nitrogen is controlled and that from non-protein sources utilized more efficiently via microbial proteins; and considerable synthesis of vitamins takes place. This aspect of the physiology is as fascinating to the investigator as it is important for the husbandman. Further advances should help to clear our understanding of some of the so-called 'metabolic' diseases.

THE CULTURAL VALUE OF LOCAL SOCIETIES

LORD BOYD-ORR, in his presidential address to Section X (Assembly of Corresponding Societies), remarks that though all governments are clamouring for more science, human society is suffering acute indigestion from an overdose of science. For example, it is estimated that in a third world war with the weapons we already have, 90 per cent of the people in the northern hemisphere would be wiped out. One would have thought that that was plenty to be going on with, yet in government 'hush-hush' laboratories there is probably more research to improve weapons of war than in any other field.

In industry, science has increased the output per man and the total capacity for production to such an extent that although a large part of industrial potential is engaged in producing armaments, factories produce goods for peaceful uses faster than they can be dispersed and consumed, so that production has to be slowed down with resulting unemployment which, in the United States where technology is most advanced, at present exceeds five million. To find work for people is now a major domestic political problem. But science still advances. It is estimated that when automation and other improvements foreshadowed are applied, one man will be able to produce as much as four or five at present.

Equally great is the advance in biological science. Where modern medicine has been applied, the expectation of life at birth has increased by twenty years since 1900. It is now being applied in all countries and in forty years the present population of the world is likely to be doubled, and doubled again in the succeeding thirty years. Yet medical research is being intensified—and rightly so. But too little thought is being given to how long the Earth will be able to support its human inhabitants.

Thus, in one generation, the advance of science has made war obsolete unless, of course, our civilization lacks the intelligence to avoid committing suicide. It has lifted the burden of labour from man's shoulders and changed scarcity, with inevitable poverty, for the majority of the people in the world to one of potential abundance for all mankind. It has made it possible to free the human family from most of the suffering and premature death which has afflicted it since man first appeared on the Earth.

What is needed to-day is, not more science, but changes in the structure of society to enable people to enjoy the rich fruits science has already made available. Governments—even to some extent, totalitarian governments—cannot bring about big changes until people realize the need for them. The British Association, especially by its presidential addresses, is doing much to enlighten the public on the powers of science and the problems they have created. It is suggested that this should now be its main function.

Several sections might consider common big issues and report their findings in non-technical language. Section X, which consists of about 170 allied societies the members of which represent the more intelligent part of the population of Britain, might consider the changes needed to adjust society to the new atomic age. By doing this it would promote knowledge, wisdom and benevolence, or in other words 'culture', which this scientific age so sadly lacks.

The British Association can perform an even more valuable ervice than it has done in the past by adapting its meetings to throw the searchlight of science on world affairs.

THE GLASGOW REGION

The Glasgow Region

A General Survey. Edited by Prof. Ronald Miller and Dr. Joy Tivy. Pp. xix + 325 + 20 plates. (Glasgow: Local Committee of the British Association for the Advancement of Science, 1958.)

WHILE it can scarcely be said that the various centres visited by the British Association vie with one another in the production of a handbook to the neighbourhood, the local committees have certainly succeeded in producing a valuable series of books, impressive both in quality and in size. The handbook for the Glasgow meeting is no exception. It is a very substantial volume, well supplied with plates and other illustrations, and embellished with the University and City arms on the covers.

The volume has been prepared under the editorship of Prof. Ronald Miller and Dr. Joy Tivy, of the Department of Geography in the University of Glasgow, who emphasize in the foreword that it has to serve a double purpose: it must introduce the region to the visitor and it must give the local reader food for thought, thus providing for both divisions of the British Association membership. This they have succeeded in doing, mainly by means of a series of chapters surveying different aspects of the scene.

Prof. Miller opens with a chapter on the geography of the region. This is followed, quite naturally, by a résumé of the geology by Prof. T. Neville George. C. A. Halstead deals with the climatology. The chapter on land utilization is divided into three parts, written by Prof. John Walton (vegetation), Prof. Donald S. Hendrie (agriculture) and J. E. James (forestry) respectively. Biology of the Clyde and its associated waters is dealt with by Dr. W. D. Russell Hunter, who also provides some notes on the land animals of the area. The Clyde in prehistory and in the Roman period is discussed by Dr. Horace Fairhurst and Dr. Anne S. Robertson respectively. Chapters on Glasgow itself and its history to 1750 (Prof. George S. Pryde) and the industrial and commercial developments (John B. S. Gilfillan and H. A. Moisley) bring the story to 1914. There follow chapters on the engineering industries (Drs. James Orr and Sarah C. Orr), fuel and power (Dr. R. Common on coal and gas, and D. R. Diamond on electricity and petroleum) and the economy of Glasgow (Prof. Alec Cairncross). Human problems are the subject of chapters on population distribution (Dr. Joy Tivy), the Glasgow overspill problem (Berenice D. Baker), transport (John F. Sleeman) and Glasgow's spheres of influence as a regional capital (H. A. Moisley). The histories of the University of Glasgow and of the Royal College of Science and Technology are briefly summarized by Prof. John D. Mackie and Charles G. Wood respectively, A. McLaren Young surveys the fine arts and Catherine B. Smith provides brief notes on research institutions in the area.

"The Glasgow Region" is a worthy addition to the series of handbooks prepared by the enthusiastic and hard-worked local committees in the cities visited by the British Association. For the teacher of geography they are veritable mines of information, up to date and authoritative, for regional studies; for the visiting member of the British Association they are equally useful for reference purposes, and also as reminders of many interesting and valuable occasions. There is no index.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY, GLASGOW

NEW ENGINEERING BLOCK

IN the years between the two world wars, the engineering department of the Royal Technical College, Glasgow, established an international reputation for teaching and research. It seems appropriate, therefore, that the recently completed first phase of a long-term scheme of development of the College which, since 1956, has been called the Royal College of Science and Technology, should be a new building for engineering. The College is one of the leading technological institutions in Britain selected for major expansion in accordance with the national plan for higher technological education. It has been affiliated to the University of Glasgow for some forty-five years and was recognized as a university college in 1919.

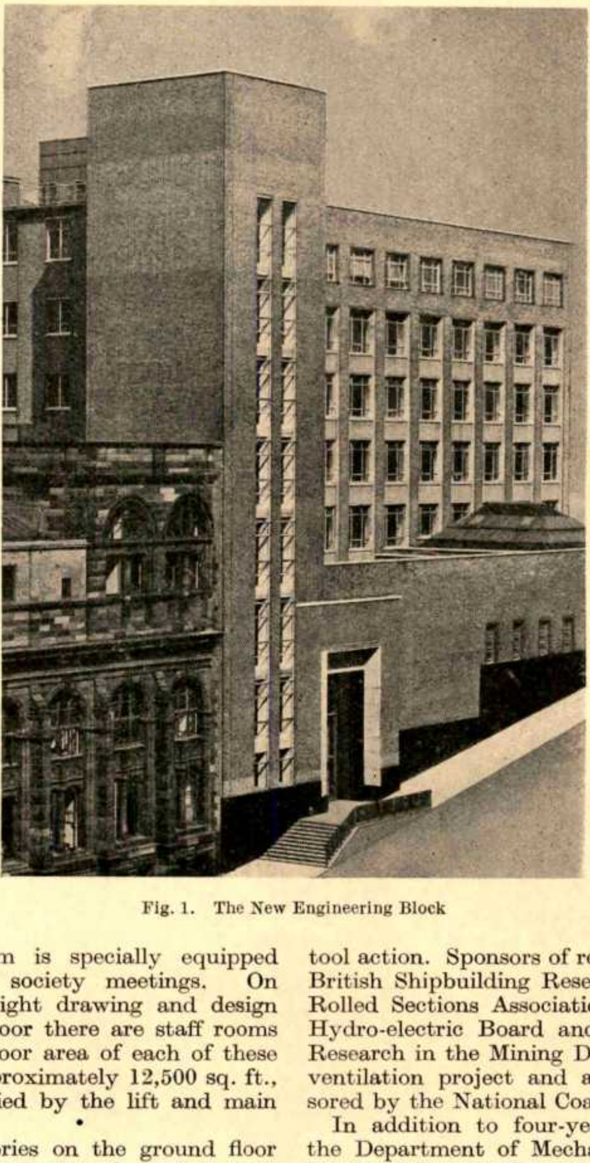

Fig. 1. The New Engineering Block

The new building accommodates the Department of Mechanical, Civil and Chemical Engineering and the Department of Mining. It is a seven-story building adjoining the older buildings of the College. The laboratories containing heavy equipment are housed on the ground floor, which extends beyond the line of the upper floors. Smaller teaching and research laboratories occupy the first floor. The second floor accommodates fourteen rooms which can be used as lecture rooms, small laboratories or research rooms, as required. The Mining Department occupies the whole of the third floor and, in addition, has a laboratory in the basement of the building. The main lecture rooms are on the fourth floor and are eight in number; one of them is specially equipped for general lectures and society meetings. On the fifth floor there are eight drawing and design offices, and on the sixth floor there are staff rooms and central offices. The floor area of each of these floors above the first is approximately 12,500 sq. ft., excluding the space occupied by the lift and main stairway.

The eight large laboratories on the ground floor are equipped for teaching and research work in connexion with hydraulic structures and concrete, hydraulic machines, static testing of materials and components (loads up to 250 tons), dynamic testing of materials and components together with hardness testing and the compression testing of masonry, production engineering, aerodynamics, machine dynamics and heat engines, respectively. Thus, the production engineering or machine tool laboratory contains a variety of modern machine tools such as lathes, milling machines and grinding machines. The equipment of the aerodynamics laboratory includes wind tunnels, while that of the machine or technical dynamics laboratory includes electrical and hydraulic servo mechanisms and an analogue computer, in addition to equipment for studying vibrations and balancing of machinery. Smaller laboratories on the first and second floors are equipped for advanced teaching and research in soil mechanics, theory of structures and experimental stress analysis, chemical engineering and metrology, as well as for teaching elementary mechanics of machines, dynamics, statics and strength of materials and hydraulics.

A variety of research projects is being conducted in the laboratories, and facilities are provided to enable students to work for higher degrees. Notable among the research activities are: hydraulic studies using scale models, contact pressure on foundations, non-destructive testing of concrete, circulation in water-tube boilers, transportation of solids by fluids, corrosion fatigue of steel in sea-water, load-carrying capacity of thin-walled structures, behaviour of shell structures, transients in heat transfer and cutting tool action. Sponsors of research projects include the British Shipbuilding Research Association, the Cold Rolled Sections Association, the North of Scotland Hydro-electric Board and the Ministry of Supply. Research in the Mining Department includes a mine ventilation project and a subsidence project sponsored by the National Coal Board.

In addition to four-year undergraduate courses, the Department of Mechanical, Civil and Chemical Engineering provides one-year and evening post-graduate courses for practising engineers, the subjects of which include nuclear power, production engineering, structural engineering and environmental control engineering.

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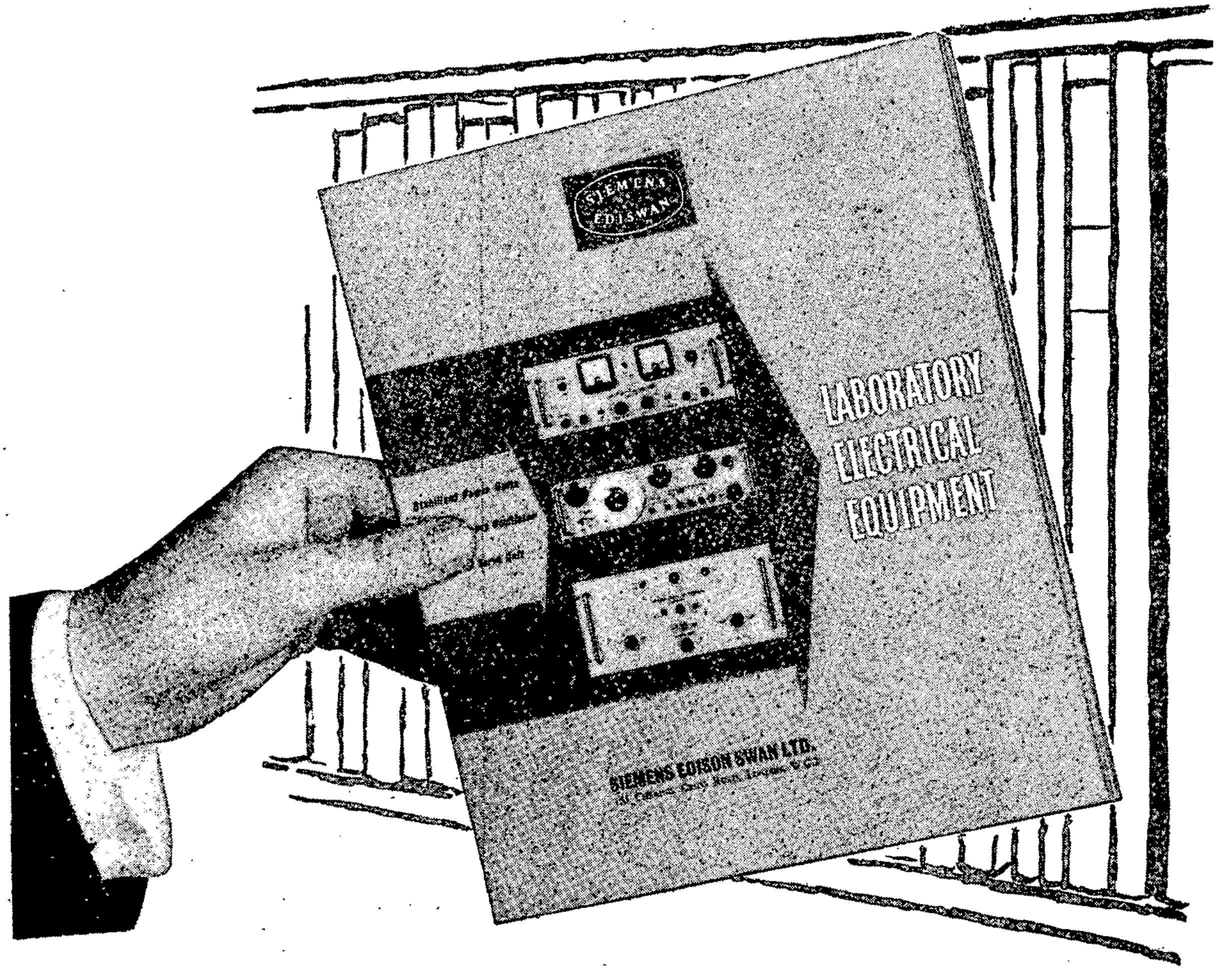

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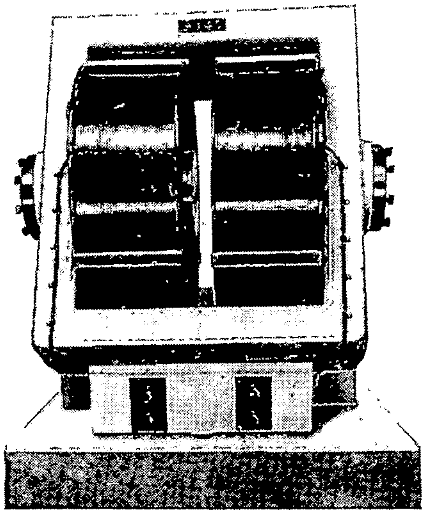

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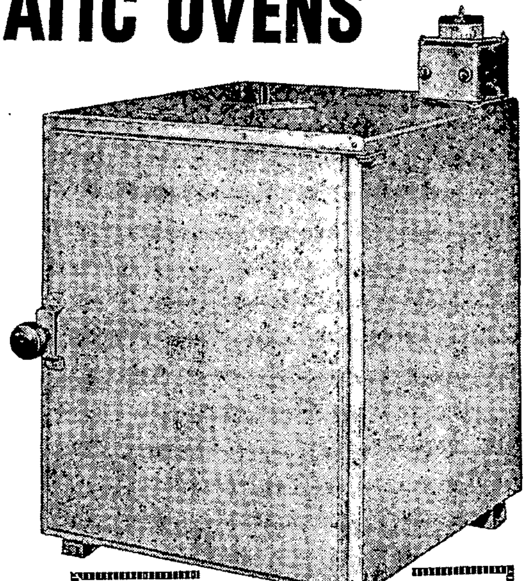

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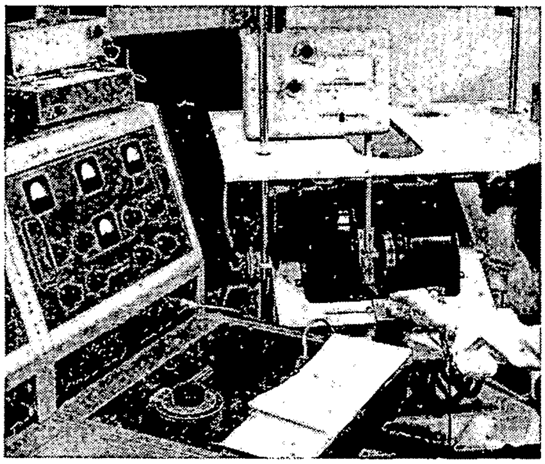

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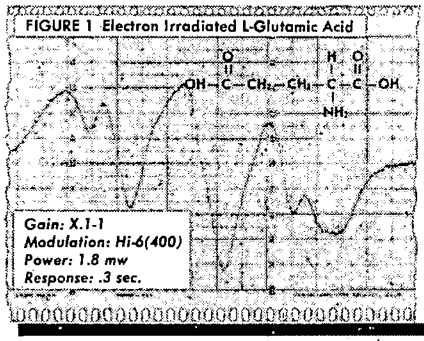
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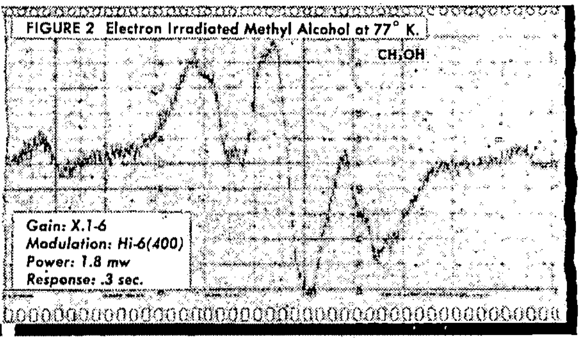
FIGURE 2 Electron Irradiated Methyl Alcohol at 77° K.

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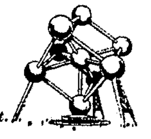

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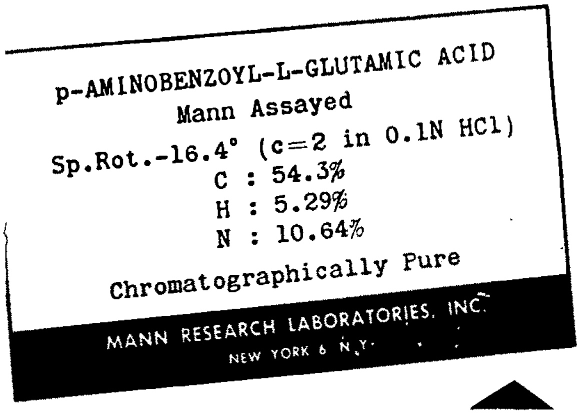

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(*Continued from page* 572)

It was observed that injuries to the brain of the graft as well as the host were far more serious than in homografts; they deserve careful study in both cases, but especially in homografts, because some of the grafted chicks hatch. Deformities and imperfections affecting the upper jaw were also quite common. This particularly applies to the duck-to-chicken transplants, where an under-developed or even vestigial upper bill was a regular occurrence. Deficiencies in the cartilage and bone-forming tissues were pronounced and resulted in an incomplete skull. Another interesting observation is that incubation periods lasting several days more than the normal were recorded. Thus the incubation period of one grafted chicken embryo lasted for 26 days and of a duck embryo for 33 days; both embryos showed a considerable lag in development.

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April 11.

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SYNTHESIS OF DEOXYRIBONUCLEIC ACID IN EXTRACTS OF MAMMALIAN CELLS

By Prof. J. N. DAVIDSON, Dr. R. M. S. SMELLIE, Dr. H. M. KEIR and A. HOPE McARDLE
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STUDIES on the incorporation of radioactive precursors, such as ^{14}C-formate, ^{14}C-adenine and ^{32}P-phosphate, have shown that Ehrlich mouse ascites tumour cells can synthesize deoxyribonucleic acid under *in vitro* conditions[1]. A more specific precursor of deoxyribonucleic acid, however, is thymidine, which in the form of ^{15}N-thymidine[2], or ^{14}C-thymidine[3], has been shown to be incorporated readily into deoxyribonucleic acid in the rat[2], the chick embryo[3], bone marrow cells[4], isolated thymus nuclei[4], onion root tips[5], and tissue cultures[6]. With the production of thymidine labelled with tritium[7], a new tool has become available for the study of the biosynthesis of deoxyribonucleic acid, and tritiated thymidine has been used by several groups of workers both in the study of chromosome reproduction[7,8] and in the investigation of the formation of deoxyribonucleic acid in regenerating rat liver[9].

Tritiated thymidine obtained from Schwarz Laboratories, Inc., was added to a suspension of Ehrlich ascites tumour cells incubated *in vitro* for 2 hr. in ascitic fluid and the cells processed by methods previously employed[1]. The deoxyribonucleic acid-protein precipitated by perchloric acid from the alkaline digest was treated with 0·5 *N* perchloric acid at 70° for 20 min. to extract the deoxyribonucleic acid, and the extract, after neutralization with potassium hydroxide and removal of potassium perchlorate, was used for determination of deoxyribonucleic acid by measurement of the extinction at 268 mμ in the Beckman spectrophotometer and for assay of tritium in a windowless flow counter.

The tumour cells incorporate (4-^{3}H) thymidine readily into the deoxyribonucleic acid (Table 1). When the cells (including the nuclei) are disrupted in 0·25 *M* sucrose-phosphate buffer by means of an ultrasonic generator[10] the suspension of cellular debris still shows good, though diminished, incorporation. On centrifugation of this material, higher activity is found in the supernatant fluid than in the sediment, and the high activity of the supernatant fluid persists after all particulate matter has been removed by high-speed centrifugation ('Spinco' ultracentrifuge) at 105,000 *g* (Table 1).

Table 1. Incorporation of (4-^{3}H) Thymidine into the Deoxyribonucleic Acid of Intact and Sonically Disrupted Preparations of Ehrlich Ascites Tumour Cells

The incubations were, for 2 hr., in a medium containing 0·25 *M* sucrose, 0·1 *M* phosphate buffer *p*H 7·4, 2·5 μmoles/ml. adenosine triphosphate, 2·5 μmoles/ml. diphosphopyridine nucleotide, 50 μmoles/ml. glucose 2 μc./ml. (4-^{3}H) thymidine, 4 μmole/ml. magnesium chloride and, 20 μmole/ml. sodium chloride

Fraction	Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Intact ascites cells	9,700
Sonically disrupted cells	600
Supernatant fraction (1,000 *g*) from disrupted cells	1,225
Sediment	322
Supernatant fraction after high-speed centrifugation (105,000 *g*)	1,661

Although we have used mainly a buffered solution containing 0·25 *M* sucrose and 0·1 *M* phosphate for the preparation of extracts of disrupted cells, other buffers such as Krebs–Ringer phosphate[11] or simple 0·1 *M* phosphate buffer with added magnesium chloride are also effective. The optimum *p*H is in the region of 8.

For good incorporation of ^{3}H-thymidine into deoxyribonucleic acid, adenosine triphosphate, diphosphopyridine nucleotide and glucose are necessary (Table 2). Adenosine triphosphate and diphosphopyridine nucleotide produce their maximum effect at concentrations not less than 2·5 μmoles/ml., while glucose is most effective at the relatively high concentration of 50 μmoles/ml. It may be replaced by other energy sources such as hexose diphosphate, but not by pyruvate or glutamate.

Table 2. Incorporation of (4-^{3}H) Thymidine into the Deoxyribonucleic Acid of a Particle-free Extract of Disrupted Ascites Cells in 0·1 *M* Phosphate Buffer *p*H 8 containing 4 μmoles/ml. Magnesium Chloride, 20 μmoles/ml. Sodium Chloride and 4 μc./ml. (4-^{3}H) Thymidine

Additions to extract (μmole/ml.)			Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Adenosine triphosphate	Diphosphopyridine nucleotide	Glucose	
2·5	2·5	50	8,230
0	2·5	50	262
2·5	0	50	1,550
2·5	2·5	0	1,700

Other tissues, such as chick embryo, on sonic disruption in sucrose–phosphate buffer also yield active extracts, but none has proved so effective as ascites cells. Examination of cell-free extracts from a series of rabbit tissues disrupted sonically shows that the potency of an extract varies according to the mitotic activity of the tissue from which it is derived (Table 3). These extracts have been obtained by the complete disruption of the cells, including the nuclei. A potent extract of chick embryo has also been obtained by gently homogenizing chick embryonic tissue in sucrose–phosphate buffer, centrifuging down the cell debris, including the nuclei, and subjecting the supernatant fluid to high-speed centrifugation so as to remove mitochondria and microsomes.

Table 3. INCORPORATION OF (4-^{3}H) THYMIDINE INTO DEOXYRIBONUCLEIC ACID BY PARTICLE-FREE EXTRACTS OF DISRUPTED RABBIT TISSUES AND CHICK EMBRYOS

Incubation conditions were as in Table 1 except that the (4-^{3}H) thymidine concentration was 5 μc./ml. and *p*H was 8

Tissue	Specific activity of deoxyribonucleic acid (counts/min./μmole deoxyribonucleic acid-phosphorus)
Rabbit bone marrow	2,450
Rabbit appendix	886
Rabbit liver	545
Rabbit kidney	505
Chick embryo	1,865

These findings with different tissues are in accordance with the observations of Friedkin and Wood[4] with tissue slices incorporating ^{14}C-thymidine and with our own previous findings on the incorporation of ^{32}P-phosphate, ^{14}C-formate and ^{14}C-adenine in rabbit tissues *in vivo*[12].

Evidence that the material into which the tritiated thymidine is incorporated is deoxyribonucleic acid is provided by the observations that it is insoluble in acid, precipitated by acid after alkaline incubation, can be isolated as deoxyribonucleic acid which on hydrolysis yields the expected four bases of which the thymine alone is radioactive, and is broken down by deoxyribonuclease to yield acid-soluble radioactive fragments. Moreover, when the radioactive deoxyribonucleic acid is degraded by the diphenylamine method[13], radioactive thymidine-3′ : 5′-diphosphate has been isolated after ionophoresis of the reaction products, as well as other radioactive components showing the spectral and mobility characteristics which would be expected of oligonucleotides containing both thymine and cytosine.

It is impossible at this stage to determine whether the incorporation of tritiated thymidine consists merely of the addition of a terminal nucleotide (or nucleotides), or whether the thymidylic acid is to be found in the body of the polynucleotide chain (both processes are known to take place in relation to incorporation of ribonucleotides into ribonucleic acid by cell-free systems[14]) ; but if, as appears probable, the incorporation of ^{3}H-thymidine is due to true synthesis of deoxyribonucleic acid, it must be assumed that the remaining three nucleotides are provided from the small pool of deoxynucleosides and deoxynucleotides which is known to exist in mammalian tissues[15]. Biosynthesis would then proceed by two major steps, the phosphorylation of the nucleosides and the assembly of the phosphorylated products into the polynucleotide chain. Although the bacterial polynucleotide phosphorylase of Ochoa[16] utilizes ribonucleoside diphosphates in the formation of ribopolynucleotides, the work of Kornberg[17] with bacterial systems suggests that the deoxynucleoside triphosphates are required for synthesis of deoxyribonucleic acid. The ability of mammalian enzymes to phosphorylate deoxynucleotides has already been demonstrated with kidney mitochondria[18], rat liver homogenates[19] and bone marrow extracts[20], and our extracts of sonically disrupted ascites cells have been found capable of converting deoxyribonucleoside monophosphates to the triphosphate stage (Keir, H. M., and Smellie, R. M. S., unpublished results).

It is clear that our system is similar to the systems found in regenerating rat liver by Bollum and Potter[9] and by Mantsavinos and Canellakis[21] for the incorporation of ^{3}H-thymidine[9] or ^{14}C-deoxynucleotides[21] into deoxyribonucleic acid, although the conditions employed by these authors are rather different from ours. Both groups found that the addition of primer deoxyribonucleic acid greatly stimulated incorporation. In our system this is not essential, since the crude particle-free extract of disrupted ascites cells already contains measurable amounts of deoxyribonucleic acid and a substantial quantity of ribonucleic acid, but addition of carrier deoxyribonucleic acid greatly increases incorporation.

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PREPARATIVE-SCALE GAS CHROMATOGRAPHY

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ANALYTICAL gas chromatography has been studied extensively during the past few years and is now used very widely. In this Department[1-5], gas chromatography has been applied also on a preparative scale (1–10 gm.) for the isolation of pure compounds from volatile mixtures which are difficult to separate in other ways. This aspect has apparently received little attention elsewhere, and few such developments are described in the literature[6-8]; it has been suggested, in fact, that any appreciable increase in column diameter would lead to a rapid decrease in efficiency. Consequently, small-scale batch processes have been employed for isolating specimens, using narrow-bore columns[7,8]. In view of the apparent scepticism about the value of the technique on a preparative scale, we wish to direct attention to our work on this type of gas chromatography, independently of the reporting of results in organic fluorine chemistry to which it has been applied. A process of high efficiency, capable of separating complex mixtures of volatile compounds in 1–50gm. quantities in a single cycle, is clearly of great potential importance, particularly if the apparatus is relatively simple. We have developed such equipment, which is used regularly on a routine basis by a large group of research workers.

We have already reported the design[1,2] and use[1-5] of a column having a total length of 16 ft. and an internal diameter of 30 mm., and packed with dinonyl phthalate/kieselguhr. The scaling up of the gas chromatographic process caused no apparent decrease in resolution. A similar column has been operated[4] with a packing of tricresyl phosphate/kieselguhr. We have since constructed an even bigger column, made of hard glass, packed with dinonyl phthalate/kieselguhr (1 : 2), and of the same total length (16 ft.; in two sections, each of 8 ft., joined by a narrow-bore bend) but having an internal diameter of 75 mm. It is mounted horizontally in electrical heaters of a type described before[10]. This column is being operated continuously as a general-purpose fractionating unit of high efficiency by colleagues in our fluorine research group. The cross-sectional area of this column is roughly six times that of the smaller preparative-scale unit, and for a series of separations under similar operating conditions the maximum sizes of samples have been about six times those for the smaller column. The actual quantity of any mixture which may be separated in either type of column depends chiefly on the differences in retention times between the various components present. With the larger unit, if the peaks are well apart, a charge of 50 gm., or even more, may be separated with ease. If the peaks are close, 12–15 gm. will probably represent the optimum quantity. As with all columns, an efficient pre-heater is necessary to volatilize the charge rapidly. Table 1 lists a few separations, typical of many examples with analogous compounds, which have been carried out using the larger column.

The design of the apparatus is essentially the same as that described earlier[1,2]. However, one important modification to the detector unit has been necessary. The sensitivity of katharometer detectors fell rapidly with increasing velocity of the gas. One solution to this problem would have been to use a by-pass system, passing only a small portion of the gas through the detector. However, experiments with such a system showed that in certain cases some mixing occurred in the collecting trap when two peaks which were close together were being eluted, despite the indication of a complete separation by the detector unit. It was found rather troublesome to eliminate this effect completely, and it appeared desirable to pass the total effluent from the column through the detector. Preliminary experiments, using glass katharometers of wide bore, indicated that although a normal signal could be obtained by increasing the diameter of the sensing channel to compensate for the high rates of flow of the carrier

Table 1. SEPARATIONS USING A COLUMN (16 FT. × 75 MM. INT. DIAM.) PACKED WITH DINONYL PHTHALATE/KIESELGUHR

Components of Mixture	Total charge (gm.)	Weight recovered (gm.)	Boiling point (°C.)	Retention time (min.) (start of peak)	Nitrogen flow-rate (l./hr.)	Temperature of column (°C.)
Perfluoro*cyclo*hexane	70·0†	27·3	52	15	50	83
Diethyl ether		30·1	34	65		
Perfluoro*cyclo*hexa-1 : 4-diene	14·4‡	1·2	57	40	42	80
Perfluoro*cyclo*hexa-1 : 3-diene		1·9	63	70		
4*H*-Nonafluoro*cyclo*hex-1-ene		6·1	69	160		
3*H*-Nonafluoro*cyclo*hex-1-ene		3·3	70	200		
1*H* : 5*H*-Hexafluoro*cyclo*hexa-1 : 4-diene	20·0§	6·2*	71	95	48	110
1*H* : 4*H*-Hexafluoro*cyclo*hexa-1 : 4-diene			75			
Pentafluorobenzene		9·5	89	215		
1*H*, 4*H*/5*H*-Heptafluoro*cyclo*hex-1-ene		2·1	103	320		
1*H* : 5*H*-Hexafluoro*cyclo*hexa-1 : 4-diene	17·0	8·7	71	225	50	71
1*H* : 4*H*-Hexafluoro*cyclo*hexa-1 : 4-diene		5·8	75	285		

* Not separated at this temperature.
† This mixture is an azeotrope used to remove perfluoro*cyclo*hexane from polyfluoro*cyclo*hexanes (ref. 3).
‡ Obtained by dehydrofluorination of 1*H* : 3*H*-decafluoro*cyclo*hexanes (refs. 1 and 4).
§ Obtained by dehydrofluorination of 1*H* : 2*H* : 4*H* : 5*H*-octafluoro*cyclo*hexanes (ref. 11).

gas used, care was necessary to avoid turbulence if the detector was to remain stable. Accordingly, a katharometer was made from a brass block by cutting in it a streamlined channel with diameter increasing gradually along its length to a maximum of approximately 1 in. and then gradually tapering down, finally terminating in a nozzle of approximately 0·25 in. diameter. In the widest part of the channel were fixed two disks of nickel gauze; between these disks (which were at right-angles to the flow of gas) was screwed an insulated metal former on which was fixed a tungsten spiral. The dead spaces between the disks and the inlet and outlet were packed with glass wool. A similar cell, in the same block, was incorporated in the gas inlet-stream, the resistances of the tungsten wires being the same. The wires form two arms of a d.c. Wheatstone bridge, powered by a 6-V. accumulator, and the out-of-balance potential was fed directly to a recorder (Honeywell-Brown, 0–1 mV.), no further amplification being necessary. A sensitivity control normally run at half the maximum was inserted before the recorder. This system is both sensitive and stable at flow-rates of gas of 50 l./hr., and minor components of the mixtures which are scarcely visible when collected in the traps may be detected with ease.

The collecting traps are of the normal design with a side inlet and central outlet. They are 60 mm. in diameter, and are cooled in liquid oxygen. It is desirable to distil the separated components from the traps *in vacuo*, since trace quantities of the packing material are progressively removed from the column in the gas stream. Recoveries of material of 80–90 per cent are obtained with ease, and if special precautions (for example, the introduction of samples *via* a vacuum line) are taken to avoid handling losses, the recoveries approach 100 per cent.

Theoretical plate determinations on each of the preparative-scale columns and on a typical analytical-scale column showed no apparent fall in efficiency with increase in column diameter. It would appear that even bigger columns could be operated successfully, particularly as more stationary phases become available. It can be seen from our results that as a practical means of separating volatile mixtures, preparative-scale gas chromatography is a remarkably successful technique. Certainly much of the recent work of our fluorine research group would have been very difficult if not impossible to carry out without it.

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INCORPORATION OF AMINO-ACIDS BY DISRUPTED STAPHYLOCOCCAL CELLS

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IN 1953, Gale and Folkes[1] described a preparation of disrupted cells of *Staphylococcus aureus* which, in the presence of adenosine triphosphate and an energy generating source, was able to incorporate amino-acids into the trichloracetic acid precipitable fraction. Subsequent experiments[2] showed that the course of incorporation of glutamic acid labelled with carbon-14 into this fraction varied with the conditions of incubation. Two conditions in particular were studied: condition 1, in which glutamic acid was the only amino-acid added to the medium; and condition 2, in which a mixture of eighteen amino-acids was added, glutamic acid only being labelled. Under condition 2 the incorporation of glutamic acid continued at a steady rate for several hours and an increase in 'protein'-nitrogen and certain enzymic activities could be demonstrated.* Under condition 1 no significant change in the 'protein' content of the preparation could be measured and the rate of incorporation, initially faster than that under condition 2, decreased rapidly so that incorporation ceased after approximately 60 min. If the disrupted cells were washed free from medium after incorporation under condition 1 had ceased, and then re-incubated in the presence of an energy source and unlabelled glutamic acid, a partial release of the incorporated radioactivity occurred; this release did not take place if the second incubation was carried out in the presence of energy source alone, unlabelled glutamic acid alone, or energy source together with unlabelled glycine or aspartic acid. It was suggested that incorporation under condition 1 could not be taken as a measure of protein synthesis, but that the results were consistent with the hypothesis that the process involved one amino-acid and arose from substitution of corresponding residues in preformed protein by an exchange reaction. Since incorporation under condition 1 could be markedly decreased by removing nucleic acid from the cell preparation, it was further suggested that such exchange reactions involved nucleoprotein complexes.

The trichloracetic acid precipitate obtained from intact or disrupted staphylococcal cells includes cell walls, and it is now known that these walls contain a hexosamine peptide polymer in which glycine, D- and L-alanine, L-lysine and D-glutamic acid are the principal amino-acids[3,4]. The recent demonstrations

Table 1. INCORPORATION OF AMINO-ACIDS INTO THE CELL-WALL FRACTION AND INTO MATERIAL FROM *Staphylococcus aureus* (STRAIN DUNCAN) INSOLUBLE IN HOT TRICHLORACETIC ACID IN INTACT AND DISRUPTED CELL PREPARATIONS

Amino-acid	Specific activity (counts/min./mμmole)	Incorporation in intact cells*		Incorporation in disrupted cells†	
		Counts/min. TCA ppt.	Per cent radio-activity in wall fraction	Counts/min. TCA ppt.	Per cent radio-activity in wall fraction
Glutamic acid	1,340	6,165	71	1,249	13
		(12,503)‡	60		
Glycine	534	5,458	91	1,081	40
		(13,445)‡	94		
Lysine	1,710	5,391	51	2,375	20
Alanine	431	2,882	70	371	25
Valine	1,175	2,221	13	1,092	9
		(3,802)‡	15		
Leucine	1,170	2,470	13	1,257	12

* Intact cells incubated at 0·5 mgm. dry weight/ml. in phosphate-saline *p*H 7·0 containing 1·5 per cent (w/v) glucose and one of the above amino-acids (L-isomer, generally labelled with carbon-14) at 0·01 μmole/ml. except in cases marked ‡, where amino-acid concentration was increased ten times. Incubation for 60 min. at 37°. TCA ppt. = material from 1·0 mgm. dry weight of cells which is insoluble in hot 5 per cent trichloracetic acid; wall fraction separated by the method of Hancock and Park (ref. 6).

† Disrupted cells (ref. 2) incubated at 0·7 mgm. dry weight/ml. in phosphate–saline *p*H 6·25 containing adenosine triphosphate, hexosediphosphate and one amino-acid as for intact cells.

that intact *Staphylococci* incubated with glucose can incorporate these amino-acids, added either singly or in simple mixtures to the medium, into cell wall structures[5,6] and that incorporation in animal and *Tetrahymena* cells involves a polyribonucleotide component with which amino-acids can combine in a reversible manner[7], make it desirable to re-assess and re-investigate the nature of 'condition 1 incorporation' in the disrupted staphylococcal cell preparation.

Incorporation into the Cell Wall Fraction

Table 1 shows the incorporation of certain amino-acids, each investigated under condition 1 as the only amino-acid added to the incubation medium, into the material insoluble in hot trichloracetic acid and the cell-wall fraction (separated by the method of Hancock and Park[6]) of intact *Staphylococcus aureus* strain Duncan and disrupted cell preparations made from it. With intact cells in the presence of glucose, more than 90 per cent of the glycine and more than 50 per cent of the lysine, alanine and glutamic acid is found in the cell-wall fraction, which may contain part of the cell membrane in addition to the true outer wall. In the disrupted cell preparation, the amounts of the 'wall amino-acids' which are incorporated relative to valine or leucine are smaller, and the proportion residing in the wall fraction markedly less than in the intact cell. It would appear that one result of exposure to supersonic vibration is reduction of the incorporation of amino-acids into the wall structure. The proportion of the incorporated glutamic acid found in the wall fraction varies with the preparation and has ranged from 8 to 35 per cent (mean 19 per cent), for ten preparations. The preparation used in Table 1 was exposed for the time necessary to obtain good depletion of nucleic acid[2]; shorter exposure results in a higher proportion of the incorporated glutamic acid appearing in the wall fraction.

Reversible Incorporation

Whereas the earlier experiments were carried out with material insoluble in trichloracetic acid, the nature of the bound glutamic acid not in the wall fraction has now been investigated by electrophoresis of extracts of the cells on starch columns as described by Pardee, Paigen and Prestidge[8]. After incorporation, the disrupted cell preparation is washed exhaustively in water and then subjected to a further 4-min. exposure to supersonic vibration to disintegrate its structure. The disintegrated material is centrifuged at 5,000 *g* for 30 min. to remove cell-wall fragments, the supernatant material inserted in the starch column and subjected to 600 V./30 cm. for 4½ hr. in 0·05 *M* *tris* buffer at *p*H 7·6. At the end of this period, the column is cut into 1-cm. sections and each section eluted with 5 ml. of water. The nucleic acid content of the eluates is measured by optical density at 260 mμ, the eluates dried and their radioactivity determined. The distribution of radioactivity along the starch columns varies with the conditions of incubation during incorporation.

Fig 1*A* shows that incorporation under condition 2 gives rise to a distribution of glutamic acid such that more than 60 per cent of the radioactivity lies in the slow-moving fractions (moving less than 10 cm. from the origin); if incorporation takes place under condition 1 (Fig. 1*B*), then 70–80 per cent of the radioactivity lies in fast-moving fractions (11–15 cm. from the origin) close to the nucleic acid front. Fig. 1*C* shows that there is no significant alteration in this latter distribution if the disrupted cell preparation is afterwards incubated with the energy source alone or unlabelled glutamic acid alone, but some 50 per cent of the radioactivity is released, and can be recovered from the medium, if the second incubation takes place in the presence of an energy source and unlabelled glutamic acid. No such reversal has been observed in the slow-moving fractions whether incorporation has taken place under condition 1 or 2; the eluates from these fractions have ultra-violet absorption spectra typical of nucleoproteins and their radioactivity is precipitated by 5 per cent trichloracetic acid in the cold.

The nature of the fast-moving fraction which becomes reversibly labelled when incubation takes place with L-glutamic acid under condition 1 is now being investigated. The α-carboxyl group is not attacked by ninhydrin, but 96 per cent of the glutamic acid is released by treatment with 0·01 *N* potassium hydroxide for 5 min. at 30° or *N* hydrochloric acid for 60 min. at 100°. Treatment with ribonuclease releases 30–40 per cent of the glutamic acid. Incubation with L-glutamic acid decarboxylase shows that the glutamic acid is not all in the L-form: 40–45 per cent of that released by acid hydrolysis assays as the L-isomer. 90 per cent of the radioactivity of the eluate from the fast-moving fraction is left in the aqueous phase after shaking with aqueous phenol[7]; addition of trichloracetic acid in the cold to 5 per cent final concentration precipitates less than 2 per cent of the radioactivity. From these results it would appear that the labelled fraction is complex, but the radioactivity is quantitatively eluted from 'Ecteola' cellulose[9] columns by 0·05 *M* *tris* buffer at *p*H 7·6. If the original incubation mixture contains unlabelled glutamic acid but adenine or uracil labelled with carbon-14, the fast-moving fraction and the eluate from 'Ecteola' cellulose become labelled.

When disrupted cell preparations are labelled with glutamic acid under condition 1, washed and then re-incubated under condition 2 in the absence of added glutamic acid, an amount of label ranging from 30 to 50 per cent of the total in the fast-moving fraction is

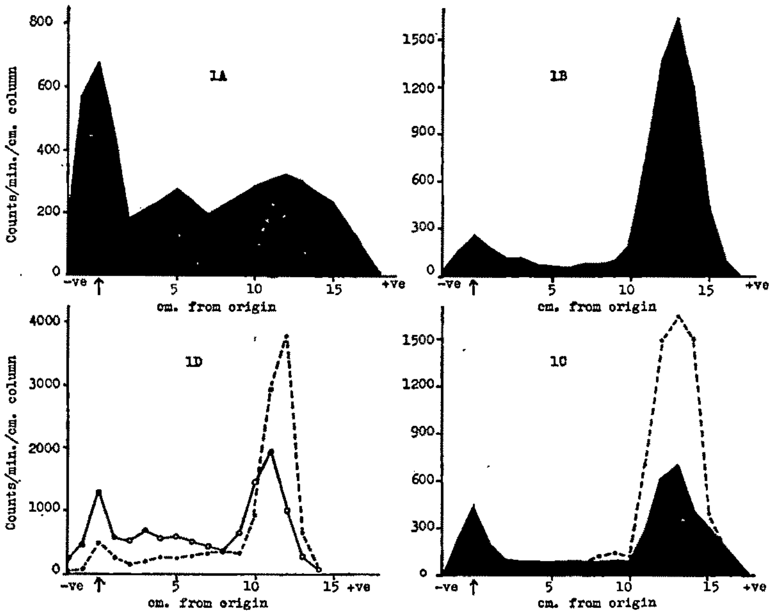

Fig. 1. Distribution, after electrophoresis on starch columns, of radioactivity in extracts from disrupted staphylococcal cells after incubation with glutamic acid labelled with carbon-14, and an energy-generating source

1*A*. Incubation under condition 2 (ref. 2) (18 amino-acids present) with 0·1 μc. glutamic acid (specific activity 0·9 mc./mmole)/ml. for 2 hr. at 37°. Total counts/min. eluted = 5,503 ; extract from approximately 5·5 mgm. dry-weight disrupted cells

1*B*. Incubation under condition 1 (glutamic acid being the only amino-acid added) with 0·1 μc. glutamic acid (specific activity 11·7 mc./mmole)/ml. for 1 hr. at 37°. Total counts/min. eluted = 8,329 ; extract from approximately 2·1 mgm. dry-weight disrupted cells

1*C*. As for 1*B* ; disrupted cell preparation washed after incubation as 1*B* and re-incubated for 1 hr. in the presence of the energy-generating source alone (broken line) or with the addition of 0·4 μmole unlabelled glutamic acid/ml. (solid block). Incubation with unlabelled glutamic acid without energy-generating source gives distribution significantly the same as the broken line. Total counts eluted = 7,894 (broken line), 4,193 (solid block)

1*D*. (i) Broken line : incubation as for 1*B* ; total counts/min. eluted = 11,715 ; extract from approximately 2·6 mgm. dry-weight disrupted cells. (ii) Continuous line : redistribution of activity in (i) obtained after preparation is washed and re-incubated for 1 hr. under condition 2 in absence of added glutamic acid ; total counts/min. eluted = 11,601

Cell extracts run in all cases for 4½ hr. in starch columns at 600 V./30 cm. in 0·05 *M* *tris* buffer *p*H 7·6 ; columns cut into 1 cm. sections, each section eluted in 5 ml. water and dried for radioactivity determinations. Abscissæ = radioactivity of eluates in counts/min. per section

transferred from that fraction to the slower-moving fractions (see Fig. 1*D*). We are at present endeavouring to investigate the relationship of the fast-moving component(s) to "soluble ribonucleic acid"[7] on one hand, and to the uridine-hexosamine-peptides that accumulate when cell-wall synthesis is inhibited by penicillin[4], on the other.

It is now clear that about 75 per cent of the bound ^{14}C-labelled glutamic acid in extracts of disrupted cells after incorporation under condition 1 is not precipitated by hot 5 per cent trichloracetic acid. The trichloracetic acid precipitate of disrupted cells contains the cell-wall fraction and the slow-moving electrophoretic fractions, whereas the bulk of the fast-moving fraction is not precipitable with trichloracetic acid. Reversible incorporation takes place in the fast-moving fraction or certain components of it ; the earlier suggestion that incorporation can occur by exchange reactions involving preformed proteins is therefore no longer tenable. No explanation can be put forward at present for the occurrence of reversible incorporation in the material insoluble in hot trichloracetic acid from disrupted cells previously described, and it may be that trichloracetic acid is not a suitable reagent for investigations with preparations of this description. From the present studies it appears that the main processes occurring during incorporation of glutamic acid under condition 1 result in labelling of the fast-moving electrophoretic components and (in intact cells) incorporation into cell wall structures.

Inhibitors

One of the puzzling results obtained in the course of studies of the inhibition of amino-acid incorporation under condition 1 has been the partial or 'plateau' nature of the inhibition obtained with antibiotics such as penicillin and chloramphenicol[2,10]. It is now clear that such studies, especially when glycine is the amino-acid incorporated, involve at least two series of processes : those leading to protein synthesis, and those leading to cell-wall synthesis. Inhibitors which give a plateau type of inhibition presumably do not affect one of these series, whereas inhibitors, such as aureomycin and certain benzimidazole derivatives[10], which bring about complete suppression of incorporation, must affect both series. Chloramphenicol inhibits protein synthesis[11] but not the synthesis of cell-wall peptides[5, 6]. Its action on the incorporation of glutamic acid into the nucleoprotein extracts of disrupted cells is to prevent incorporation into the slow-moving electrophoretic fractions, whereas the labelling of the fast-moving fraction is not affected. The presence of chloramphenicol during incubation thus effectively converts the distribution obtained under condition 2 (Fig. 1*A*) into that obtained under condition 1 (Fig. 1*B*) and would appear to inhibit the transfer of labelled residues from the fast-moving to the slow-moving fractions.

Incorporation Factors

The removal of nucleic acid from the disrupted cell preparation results in a decrease in its ability to incorporate amino-acids[2] and to synthesize ribonucleic acid[12] ; these properties can be restored by addition to the incubation medium of staphylococcal nucleic acid. The activity of the nucleic acid preparation in restoring amino-acid incorporation is not decreased by digestion with ribonuclease but is released in fractions which were first identified as small polyribonucleotides[13]. It was later found that the activity is due to contaminating substances present in trace amounts and provisionally called "incorporation factors"[14]. A concentrate with incorporation-factor activity has now been prepared[13] ; this preparation promotes the incorporation of a wide range of amino-acids, including those found in cell-wall peptides and others believed to occur in the protein only. The preparation has been routinely assayed by its ability to promote the incorporation of glycine under condition 1. Table 2 shows that the factor preparation stimulates the incorporation of glutamic acid into both protein and cell-wall fractions

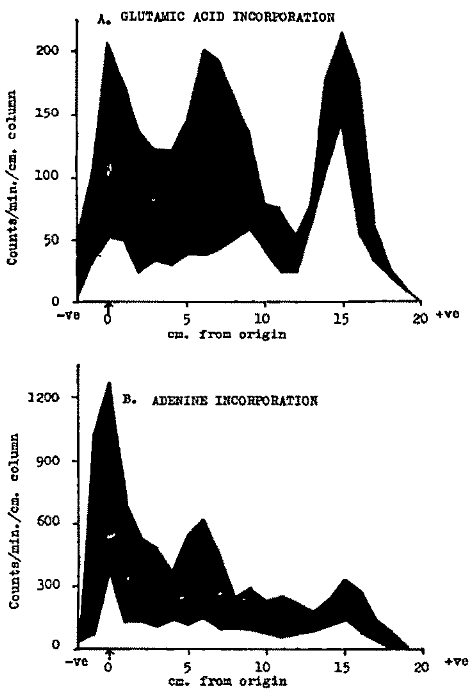

Fig. 2. Distribution of radioactivity, after electrophoresis on starch columns, in extracts of disrupted staphylococcal cells after incubation under condition 2 with (*A*) glutamic acid labelled with carbon-14, and (*B*) adenine, labelled with carbon-14, in the presence and absence of the incorporation factor preparation (ref. 12)

Procedure as for Fig. 1*A* with disrupted-cell preparation first depleted of nucleic acid by incubation with 'Streptodornase' (Lederle). Unshaded portion = incorporation in absence of incorporation factor; black portion = stimulation of incorporation by the presence of the factor preparation. Specific activity of glutamic acid in (*A*) = 0·9 mc./mmole; 103 counts/min. = 1 mμmole. Specific activity of adenine in (*B*) = 8·7 mc./mmole; dilution in course of experiment unknown

of disrupted staphylococcal cells depleted of nucleic acid.

The finding that the incorporation factor preparation is essential for ribonucleic acid synthesis[12] indicates a possible explanation for the apparent replacement of nucleic acid by the factor preparation in studies of amino-acid incorporation. Incorporation of glutamic acid is accompanied by synthesis or turnover of nucleic acid as measured by the labelling of the nucleic acid fraction, precipitable with trichloracetic acid, with adenine, guanine or uracil. Under condition 2, nucleic acid synthesis takes place at a constant rate for several hours, whereas under condition 1 the presence of labelled adenine or uracil and unlabelled glutamic acid shows that there is a limited incorporation of the bases which takes place during the first 30–60 min. of incubation only[12]. Stimulation of glutamic acid incorporation, whether under condition 1 or 2, is accompanied by a similar stimulation of adenine or uracil incorporation, and it may be that the incorporation factor preparation produces its effect on amino-acid incorporation by promoting the formation of nucleotide derivatives rather than by serving as a substitute for the nucleic acid. Fig. 2 shows the electrophoretic distribution of adenine and glutamic acid labels in extracts from disrupted cells depleted of nucleic acid, after incubation under condition 2 in the presence and absence of the incorporation factor preparation. It can be seen that the factor has stimulated incorporation of both adenine and glutamic acid into the nucleoprotein and the fast-moving fractions.

Table 2. STIMULATION OF THE INCORPORATION OF GLUTAMIC ACID BY THE INCORPORATION FACTOR PREPARATION (ref. 12)

	Glutamic acid incorporated (mμ moles)/mgm. disrupted cells		
	Condition 1		Condition 2
	Wall fraction	'Protein' fraction	'Protein' fraction
Disrupted cell preparation depleted of nucleic acid	0·05	0·196	1·50
In presence of 1 mgm. staphylococcal nucleic acid/3·0 ml.	0·35	0·79	6·71
In presence of 1 unit incorporation factor preparation/3·0 ml.	0·30	0·84	7·59

Disrupted cell preparation depleted of nucleic acid by incubation with 'Streptodornase' (Lederle, ref. 12). Incubation conditions as for Fig. 1; condition 1 for 1 hr., condition 2 for 2 hr. 'Protein' fraction = material insoluble in hot 5 per cent trichloracetic acid corrected for wall fraction.

The mechanism of protein synthesis is almost certainly very complex and recent advances have revealed some of the early stages involved in the activation of amino-acids and their reaction with polyribonucleotides and nucleic acids[7]. Similar studies in bacteria are rendered more complicated by the processes leading to the formation of cell-wall peptides, and the crude fractionation procedures so far adopted have given results difficult to interpret since both types of synthesis have occurred in the fractions. The description of methods for the separation of the wall fraction[5,6] represents a welcome advance. The work described here shows that glutamic acid may be incorporated into fractions which are not precipitated by trichloracetic acid even in the cold, and suggests that the syntheses of protein and wall peptides may possess common or similar initial stages. The processes can be dissociated at later stages by the use of inhibitors such as chloramphenicol and penicillin or by treatment with supersonic vibration, although the particular stage at which dissociation occurs is not yet defined in any of these instances. Some of the earlier results[15] with intact *Staphylococcus aureus*, in which incorporation of glutamic acid was relatively unaffected although protein synthesis was inhibited, may be explained in terms of the amino-acid being channelled into wall structures, and it is now necessary to investigate the inter-relationships of wall synthesis and protein synthesis, and to determine to what extent the two processes compete for a common amino-acid under the various experimental conditions that have been studied.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Cancer and Smoking

The curious associations with lung cancer found in relation to smoking habits do not, in the minds of some of us, lend themselves easily to the simple conclusion that the products of combustion reaching the surface of the bronchus induce, though after a long interval, the development of a cancer. If, for example, it were possible to infer that smoking cigarettes is a cause of this disease, it would equally be possible to infer on exactly similar grounds that inhaling cigarette smoke was a practice of considerable prophylactic value in preventing the disease, for the practice of inhaling is rarer among patients with cancer of the lung than with others.

Such results suggest that an error has been made, of an old kind, in arguing from correlation to causation, and that the possibility should be explored that the different smoking classes, non-smokers, cigarette smokers, cigar smokers, pipe smokers, etc., have adopted their habits partly by reason of their personal temperaments and dispositions, and are not lightly to be assumed to be equivalent in their genotypic composition. Such differences in genetic make-up between these classes would naturally be associated with differences of disease incidence without the disease being causally connected with smoking. It would then seem not so paradoxical that the stronger fumes of pipes or cigars should be so much less associated with cancer than those of cigarettes, or that the practice of drawing cigarette smoke in bulk into the lung should have apparently a protective effect.

A letter of mine in *Nature*[1] included a brief first report of some data on the smoking habits of twins in Germany kindly supplied by Prof. v. Verschuer. What was evident in these data, which concerned only males, was that the smoking habits of monozygotic, or one-egg, twins were clearly more alike than those of twins derived from two eggs. The monozygotic twins are identical in genotype and the clear difference in these data gave positive *prima facie* evidence that among the many causes which may influence the smoking habit, the genotype is not unimportant.

Unfortunately, considerable propaganda is now being developed to convince the public that cigarette smoking is dangerous, and it is perhaps natural that efforts should be made to discredit evidence which suggests a different view. Assumptions are put forward which, *if true*, would show my inference from von Verschuer's data not indeed to be false but at least to be inconclusive. I may refer to an anonymous writer "Geminus" in the *New Scientist*[2], who supports in this way "what is rapidly becoming an accepted truth—that smoking can cause lung cancer".

If it could be assumed as known facts (*a*) that twins greatly influence each other's smoking habits and (*b*) that this influence is much stronger between monozygotic than between dizygotic twins, then an alternative explanation would be afforded for the result I have emphasized. The assumptions can be supported by eloquence, but they should, for scientific purposes, be supported by verifiable observations.

Since my letter was written, however, I have received from Dr. Eliot Slater, of the Maudsley Hospital (London, S.E.5), some further data, the greater part of which concern girl twins, and in this way supply a valuable supplement to Verschuer's data, and in which, moreover, a considerable number of pairs were separated at or shortly after birth.

For the resemblance in smoking habit, these female pairs give:

	Alike	Unlike	
Monozygotic	44	9	53
Dizygotic	9	9	18

So far, there is only a clear confirmation of the conclusion from the German data that the monozygotics are much more alike than the dizygotics in their smoking habits. The peculiar value of these data, however, lies in the subdivision of the monozygotic pairs into those separated at birth and those brought up together. These are:

	Alike	Unlike	
Separated	23	4	27
Not separated	21	5	26

Of the nine cases of unlike smoking habit, only four occur among the twenty-seven separated at birth. It would appear that the small proportion unlike among these 53 monozygotic pairs is not to be ascribed to mutual influence.

There is nothing to stop those who greatly desire it from believing that lung cancer is caused by smoking cigarettes. They should also believe that inhaling cigarette smoke is a protection. To believe either is, however, to run the risk of failing to recognize, and therefore failing to prevent, other and more genuine causes.

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Density of Acetylene

The literature values for the density of gaseous acetylene are markedly discordant. The principal data, in order of publication, are summarized in Table 1; the values given are at $g = 980\cdot665$ cm./sec.^{2} unless otherwise indicated.

Table 1

Author	Ref.	Density at N.T.P. (gm./l.)	Comments
Leduc	1	1·1707	
Stahrfoss	2	1·1790	Corrected to standard *g*
Maass and Russell	3	1·1695	
Howarth and Burt	4	1·1720	Deduced from compressibility
Sameshima	5	1·1747	Probably at standard *g*
Hölemann and Hasselmann	6	1·171	

In addition, International Critical Tables give a value of 1·173 gm./l. and other authorities choose one or more of the values that have been quoted. A critical survey of the literature suggested that the true value was in the neighbourhood of 1·171 gm./l., but in view of the industrial importance of acetylene it was decided to re-determine the standard density, among other properties, by the indirect method of measuring the gas imperfection with high accuracy.

Gaseous acetylene was obtained from the National Chemical Laboratory, Teddington, the co-operation of which we are glad to acknowledge. The sample used, from the 'second batch' in the description of the preparation and purification given by Ambrose[7], was transferred to the apparatus and freed from non-condensibles.

The pressure-volume product of a sample of acetylene was accurately determined at several pressures between 230 mm. and 50 mm. of mercury and the second virial coefficient deduced from the slope of PV/P. The apparatus and the procedure were essentially as reported previously[8]. Expansion and compression values were taken in runs at 0° C., 20° C. and 40° C. The acetylene came in contact with 'Pyrex' surfaces, a tungsten reference point and considerable areas of grease-free mercury. At ordinary laboratory temperatures and in normal illumination no change suggestive of decomposition occurred: in the working apparatus the product PV of a sample of acetylene at 250 mm. pressure remained constant to better than 1 in 100,000 for periods of weeks. From the PV/P lines, after making allowance for the compressibility of the reference gas (nitrogen) and all reductions to standard conditions, the second virial coefficients can be deduced as:

Temperature (° C.)	B (cm.^{3}/mole)	
0	-191	error ± 1 cm.^{3}/mole
20	-158	
40	-133	

In the experimental range 50–230 mm. the results fit the equation

$$PV = RT + BP \text{ per mole}$$

so that the gaseous density may be expressed as $MP/(RT + BP)$ gm./l. If these relations hold up to 760 mm., then the densities of acetylene (molecular weight 26·038, $R = 0{\cdot}082054$ litre atm./deg. C. mole) at the working temperatures are:

0° C.	$1{\cdot}1716_7$	gm./l. at 1 atmosphere
20° C.	$1{\cdot}0895_9$	
40° C.	$1{\cdot}0185_6$	(error ± 0·00005)

We regard linear extrapolation from the working range to 760 mm. as perfectly acceptable. The observed PV values fit a linear pressure relation within 1–2 parts per 100,000: if there is to be significant curvature before 760 mm. is reached some portion of this would be detectable between 50 and 230 mm. Previous work[9] over the range 190–820 mm. with carbon dioxide ($T_c = 31°$ C.) showed that the PV/P relation was linear to within 2 in 100,000 over this pressure range at 22° C. No curvature was detected even with propane ($T_c = 95{\cdot}6°$ C.); which might be expected to show a greater effect. Indeed, there is no unambiguous direct experimental demonstration of a non-linear PV/P below 1 atmosphere for any monomeric substance. An alternative approach is to consider the form of the PV/P curve as obtained from accurate high-pressure data at a reduced temperature near that of acetylene in the present experiments, that is, $T/T_c = 0{\cdot}88$–$1{\cdot}02$. The isotherm of xenon at 16·65° C. ($T/T_c = 1{\cdot}00$) over the range 20–58 atmospheres was examined by Beattie, Barriault and Brierley[10], who represent their data by an equation indicating that the PV/P relation between 0 and 1 atmosphere includes a term in P^2 which amounts to a non-linearity of 3 in 240,000. For ethane at 25° C. ($T/T_c = 0{\cdot}96$) Beattie, Hadlock and Poffenberger[11] have examined the isotherm from 11 to 40 atmospheres: by fitting a power series equation to their results it has been shown that the curvature over 0–1 atmosphere is close to 2 in 100,000 on the PV value. It seems unlikely that acetylene should show a PV/P curvature markedly greater than these values.

Taking all the evidence for the validity of the extrapolation together, we have every confidence in the quoted densities. The differential compressibility method as a means of determining density has two advantages over direct determinations: (1) Comparative insensitivity to purity of material. Previous experience emphasizes the difficulty of removing the final traces of oxygen, nitrogen, hydrogen, inert gases and carbon dioxide from experimental gases and vapours. 0·1 per cent of either hydrogen or carbon dioxide, a significant amount if the density is determined directly, is immaterial in the virial method. (2) The only absolute determination is that of the pressure required for the pressure axis of the PV/P plot. For acetylene a precision of 0·1 mm. in 100 mm. suffices.

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Production of High Concentrations of Hydrogen Atoms

RECENTLY we wished to produce high concentrations of hydrogen atoms in flowing gas at pressures of about 0·08 mm. of mercury. An electrodeless discharge is the most suitable source at this pressure, but although several attempts were made to use such discharges maintained by microwave radiation, a stable discharge could not be obtained at pressures less than 0·12 mm. of mercury with power inputs of up to 250 W. The discharge was therefore maintained using 9·7 Mc./s. radiation from a 350-W. radio-frequency oscillator, when the method described below proved very satisfactory. About 25 cm. downstream from the discharge, the atomic concentration was 50–60 per cent. This compares favourably with most values quoted in the literature, and using microwave radiation from a 'Raytheon' diathermy unit at 0·12 mm. mercury pressure, fewer than 10 per cent atoms were obtained. Atomic concentrations were measured with a Wrede gauge with an orifice of

0·13 mm. diameter, the differential pressure being measured directly with a sensitive differential Pirani bridge.

Discharges at this frequency spread very readily at low pressures, but this was overcome by fitting an electrostatic screen between the discharge tube and the exciting coil. The 'Pyrex' discharge tube was 12 cm. long and had an internal diameter of 3 cm. Before use, it was washed out with hydrofluoric acid and distilled water. Hydrogen entered along the axis of the tube and left at the other end through a tube joined at right angles to the discharge tube. The electrostatic screen consisted of four or five strips of copper foil 10 cm. long and ½ cm. wide laid longitudinally along the discharge tube, held at one end by asbestos string and at the other end by an earthed wire. A spiral of thin asbestos string was wound on to the tube in order to preserve a clearance of about 3 mm. between the earthed foil and the exciting coil.

The coil consisted of six turns of 8 mm. copper tubing wound so as to give a 3 mm. clearance all around the tube. A variable air-condenser was connected across the coil and adjusted to give the brightest discharge. Using damp hydrogen, the bright crimson discharge was completely contained within the discharge tube. When the earthed wire of the screen was disconnected, the discharge spread more than 1½ metres down the line.

The discharge was struck with the help of a Tesla coil, and a jet of cold air played on the tube, since this tended to collapse slightly after prolonged use. Providing no short-circuit was allowed to develop between the earthed screen and the exciting coil, this discharge tube was very satisfactory and could be used for long periods.

We wish to thank Dr. D. Roaf for suggesting the use of the screen. This work was carried out as part of Contract *AF*61(514)–1117 with the Air Research and Development Command of the United States Air Force.

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Oxidation of Ferrous Ion in Aqueous Solution by Atomic Hydrogen

IT is well known that hydrogen atoms are able to act as oxidizing agents by virtue of the high energy of formation (~ 104 kcal./mole) of the H—H bond. Thus they dehydrogenate many organic substances where C—H bond energy is only of the order of 80–90 kcal./mole.

Experimental results were obtained in aqueous solutions containing, for example, ferrous ions which were irradiated with *X*- or γ-rays[1,2] or with ultraviolet light[3,4] which led to the assumption that hydrogen atoms are formed in these systems. These atoms would then oxidize the ferrous ion to ferric. In several experiments the reaction was found to be dependent on *p*H, and Weiss[5] postulated the formation of the $H_2{}^+{}_{aq}$ ion to account for this dependence. Coulson[6] considered the stability of $H_2{}^+{}_{aq}$. Schematically the reaction may be written[3]:

$$Fe^{2+}_{aq} + (H + H^+{}_{aq}) \rightarrow Fe^{3+}_{aq} + H_2$$

To test this hypothesis we used hydrogen atoms produced by an electrodeless discharge operated at 27 Mc./s. and 0·7 kW. in hydrogen alone at 20 mm. mercury, and also in helium – hydrogen mixtures at total pressures of up to 50 mm. The hydrogen atoms thus produced were passed into the aqueous solution containing ferrous ions. Suitable blank experiments were carried out and the reducing action of the hydrogen atoms produced was measured quantitatively by reaction with silver nitrate solutions. The reduction of ferric ions in the same apparatus was also studied.

To investigate the oxidation of ferrous ions, solutions containing always 0·01 *N* ferrous sulphate and varying concentrations of sulphuric acid were treated with hydrogen atoms under constant conditions of hydrogen-pressure, discharge, rate of gas flow and duration of experiment. Qualitatively the oxidation of ferrous ion was observed and followed to 10 per cent conversion by measuring the optical density at 305 mμ. At other acid concentrations account was taken of the change in the molar extinction coefficient with simultaneous changes in *p*H and sulphate concentration. Using a lower percentage of conversion, to avoid competition with reduction of ferric ions by hydrogen atoms, the following quantitative results were obtained: with 0·7 *N* sulphuric acid, ΔFe^{3+} (m.moles/l.) = 0·54 ± 0·09. This yield remains constant to approximately *p*H 3; thus with 0·001 *N* sulphuric acid (*p*H 2·95) ΔFe^{3+} = 0·50. With 0·0005 *N* sulphuric acid (*p*H 3·30), ΔFe^{3+} = 0·31 ± 0·07 was obtained under identical conditions, indicating that if the reaction depends on *p*H, this dependence manifests itself at or above *p*H 3 only where the ferrous–ferric system becomes unstable through hydrolysis. This supports the results of Allen[2] and is not in disagreement with the photochemical evidence of Lefort[4].

Our results show that hydrogen atoms, produced outside the aqueous system and introduced into it as such, are capable of oxidizing ferrous ions. The oxidation step may depend on *p*H. If so the reason for this may be in the mechanism involving $H_2{}^+$ ions as proposed by Weiss. Alternatively, the reaction may proceed through hydrogen abstraction from the hydration shell of the ferrous ion[7].

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Structure of Pyruvate in Aqueous Solution

IN a recent publication and its addendum by Dickens and Williamson and by Bellamy and Williams[1], it was reported that the infra-red spectra of lithium pyruvate and hydroxypyruvate in the solid state show no ketonic carbonyl peak, and it was suggested that these compounds exist as the hydrate, $RCH_2C(OH)_2COO^-Li^+$, in the solid and in aqueous solution and that this hydrate may be the substrate for the enzymatic reduction of pyruvate to lactate at neutral *p*H.

In contrast to solid lithium pyruvate, a solution of sodium pyruvate in heavy water shows a strong infra-red carbonyl absorption at 1,710 cm.$^{-1}$ (Fig. 1). A C—H bending peak at 1,358 cm.$^{-1}$, typical of a methyl ketone, as well as the strong carboxylate absorption at 1,610 and 1,410 cm.$^{-1}$, are also evident. Similar carbonyl peaks were found in deuterium oxide solutions of pyruvic acid (1,725 cm.$^{-1}$), α-ketoglutaric acid (1,722 cm.$^{-1}$) and sodium α-ketoglutarate (1,710 cm.$^{-1}$) and for sodium pyruvate in a potassium bromide pellet (1,715 cm.$^{-1}$). Furthermore, the ultraviolet absorption maximum of aqueous pyruvate[2] at 330 mμ is similar to that of α-ketoglutarate[3], oxalacetate[3], pyruvic acid[4] and ethyl pyruvate[4], and has the location and intensity expected for a carbonyl group in the alpha position to an unsaturated group[5].

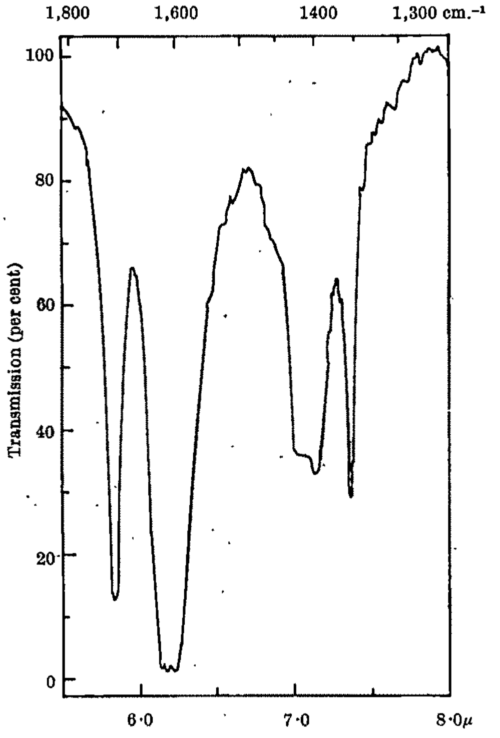

Fig. 1. Infra-red spectrum of 0·5 *M* sodium pyruvate in deuterium oxide; 0·05 mm. path-length; calcium fluoride cells; Perkin-Elmer model 21 double-beam spectrophotometer

It is concluded that pyruvate as well as pyruvic acid exist in the carbonyl form in aqueous solution, which is in accord with the low electron withdrawing ability of the negatively charged carboxylate group compared to a carboxylic acid group[6] (cf. also ref. 1) and is consistent with the chemically attractive mechanism postulated for the enzymatic reduction of pyruvate by transfer of a hydride ion from reduced diphosphopyridine nucleotide to the partially polarized, unsaturated carbonyl group[7]. The existence of solid lithium pyruvate in the hydrated form may be due to increased electron withdrawal by the concentrated positive charge of the lithium cation, or to hydration of the lithium ion by the hydroxyl groups of hydrated pyruvate in the crystal lattice, which would be favoured by the exceptionally large energy of hydration of the lithium ion.

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Faraday Fading of Earth Satellite Signals

THE rate of fading of Earth satellite signals caused by the ionospheric Faraday effect was used by British workers[1, 2] to make estimates of the integrated electron content of the ionosphere up to the height of the satellite. The values obtained were, however, apparently too high. A possible reason for this is failure to take into account the radial velocity component of the satellite which, for certain portions of the orbit, can cause an appreciable contribution to the fading.

The complete expression for the rate of fading due to the Faraday effect is:

$$\frac{d\varphi}{dt} = 2{\cdot}36 \times 10^4 . f^{-2} . B \left\{ \frac{\partial}{\partial t} (\cos\theta \sec\delta) \int_{h_0}^{h_s} N(h) dh + (\cos\theta \sec\delta) \frac{dh_s}{dt} . N(h_s) \right\} \text{radians sec.}^{-1}$$

where f is the transmitted frequency in c./s., B the Earth's magnetic field in gauss, θ the angle between the direction of propagation and the magnetic field, δ the zenith angle, and $N(h)$ the electron density per cm.^{3}. This expression arises from the fact that h_s, the upper limit of the integral (the height of the satellite), is a function of time. The rate of fading therefore consists of two terms, one of which depends upon the integrated electron content up to the height of the satellite, and the other upon the electron density at the satellite. The second term of the equation vanishes only at perigee and apogee or for a circular orbit (and, of course, when $N(h_s)$ is zero). For the general case, however, the two terms cannot be evaluated independently from observed rates of fading. A value of $\int N dh$ computed on the assumption that the rate of fading depends only upon the first term would be too high. For the two orbits used for the estimates of $\int N dh$ referred to, the contribution of the second term apparently cannot be neglected.

A detailed discussion of these considerations will be published elsewhere.

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Neutron Activation Analysis using an Internal Standard

To correct for differences in neutron flux and neutron shadowing between sample and reference a method has been developed which uses an internal standard.

Instead of irradiating a known amount of the element as a reference, two quantities a and b of the sample are irradiated, an amount c of the element X to be determined being mixed homogeneously with b.

The material subjected to analysis should contain at least one element Y, which gives rise to an isotope measurable with good accuracy and having a half-life long in comparison with the isotope of the species analysed.

When both samples are measured at a time t, after the complete decay of the species due to X, the ratio of the activities due to Y will be given by

$$\frac{A_{t(Y)}}{A'_{t(Y)}} = \frac{a}{b} \cdot \alpha \qquad (1)$$

α being a correction factor which compensates for any difference in the neutron flux received by the two samples and/or for a different neutron shadowing.

By analysis of the decay curves, the activities $A_{\tau(X)}$ and $A'_{\tau(X)}$, due to the element X, can be computed at the end of the irradiation time τ.

The specific activity of the sample, due to X, will be given by:

$$S_{\tau(X)} = \frac{1}{c}\left[A'_{\tau(X)}\,\alpha - \frac{b}{a}\,A_{\tau(X)}\right] \qquad (2)$$

and the percentage of X present by:

$$\% X = \frac{A_{\tau(X)} \times 100}{a \times S_{\tau(X)}} \qquad (3)$$

It is also apparent that simultaneous irradiation of both samples is not required.

The method is of general use but is likely to be more important in the case of neutron sources of low intensity. In this case neutron-shadowing will be greater, as it is necessary to take large samples to reach a sufficiently high activity of the analysed element. Even when using the *BR-I* reactor, however, operating at $10^{11}n$/cm.^{2} sec., neutron shadowing was observed, causing the specific activity to be low by 15 per cent when irradiating 1-gm. samples of high-alloy cobalt steel.

The method was successfully applied in the determination of vanadium and tungsten in high-alloy steels and will be described in detail elsewhere.

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Error at a Rectangular Corner in Relaxation Methods

In "Relaxation Methods in Theoretical Physics" (R. V. Southwell, Clarendon Press, 1946, p. 133) results obtained by R. W. G. Gandy, using the method of relaxation, are given for the capacity C, per unit length, of a cylindrical condenser, the cross-section of which consists of concentric squares having sides in the ratio $2\sqrt{2} : 1$. Three cases are illustrated (Fig. 54): (a) the two squares are diamondwise to each other; (c) the sides are parallel; (b) an intermediate position.

It is with cases (a) and (c) that we are here concerned. We have calculated the value of C in these two cases from the analytical solution given by F. Bowman[1], using Milne-Thomson's "Table of Elliptic Functions".

In case (a) we obtain the value 6·630 for $4\pi C$, and in case (c) the value 6·596, as compared with Gandy's result of 6·715 in both cases.

H. Jeffreys and B. S. Jeffreys[2] give, for case (c) with sides in the ratio 2 : 1, results obtained analytically and by relaxation. For this ratio of sides we have computed $4\pi C$ for case (a) and obtain 10·660, but no corresponding result obtained by relaxation appears to be available.

These results may be of interest to those using relaxation methods, as giving some idea of the amount of error that may be expected at a rectangular corner.

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Two- and Three-Dimensional Flow of Grains through Apertures

In the course of experiments on the physics of the granular mass, the rate of discharge of three size grades of a dry, sharp sand was measured (a) from wide cylindrical vessels through circular and elliptical orifices, (b) from wide rectangular vessels through long slits. In both cases the apertures were situated on the central axis of a horizontal base. The mean particle sizes P of the size grades (18 × 36, 36 × 60, 44 × 120 British Standard mesh) were 0·053, 0·037, 0·020 cm. From the measured rate of discharge Q gm./sec., a mean linear velocity v cm./sec. was calculated as:

$$v = Q/\rho A \qquad (1)$$

A cm.^{2} being the area of the aperture and ρ the particle density in gm./cm.^{3}. To find the true linear velocity of the particles from v it would be necessary to measure the bulk density of the flowing material at the orifice; this has not been done.

The data for the three-dimensional flow systems of experiment (a) were found to be well correlated in a plot of the dimensionless magnitudes,

$$\varphi = \frac{v}{\sqrt{gH}} \text{ and } \left(\frac{P}{H}\right) \qquad (2)$$

where g cm./sec.^{2} is acceleration due to gravity and H is the perimetral diameter of the aperture, defined as 4 (area)/perimeter. The elliptical apertures had equal areas of 0·32 cm.^{2} and eccentricity increasing from zero to 0·995: the velocity v decreased with increasing eccentricity. Representation (2) was adequate for accounting for aperture shape. As earlier workers have shown, this representation has the advantage that φ, which depends essentially on the aperture and not the particles, does not vary much with H, Q being nearly proportional to $H^{2\cdot5}$ for flow through circular apertures. Fowler and

Glastonbury[1] have also used the perimetral diameter for correlation of flow through apertures differing in shape.

The two-dimensional flow system of experiment (*b*) gave results which, under representation (2) (with H equal to twice the slit-width), fell on a curve distinct from that found in experiment (*a*). It can be shown that the results of experiments (*a*) and (*b*) can be reconciled by reference to the size of aperture that is just blocked by the particles.

A chain of particles having an average of about 2·7 members obstructs a slit, and a chain having about 4·3 members obstructs a circular orifice[2]. It is not unreasonable to suppose that the rate of discharge depends on the number N of chains that span an aperture, being zero for N unity. The results from experiments (*a*) and (*b*) were therefore plotted in terms of the dimensionless magnitudes,

$$\psi = \frac{v}{\sqrt{gP}} \text{ and } N \qquad (3)$$

where (in order to include the elliptical apertures)

$$N = \frac{H}{K}, \quad \begin{matrix} (K \simeq 4{\cdot}3\,P \text{ for three-dimensional flow}) \\ (K \simeq 5{\cdot}4\,P \text{ for two-dimensional flow}) \end{matrix} \qquad (4)$$

and K is the perimetral diameter of the aperture that is just blocked. The ratio of kinetic energy of a particle to the potential energy lost in falling through a particle diameter is $\frac{1}{2}\psi^2$, which is therefore a particle characteristic.

It is clear from Fig. 1 that representation (3) satisfactorily correlates the two- and three-dimensional flow systems.

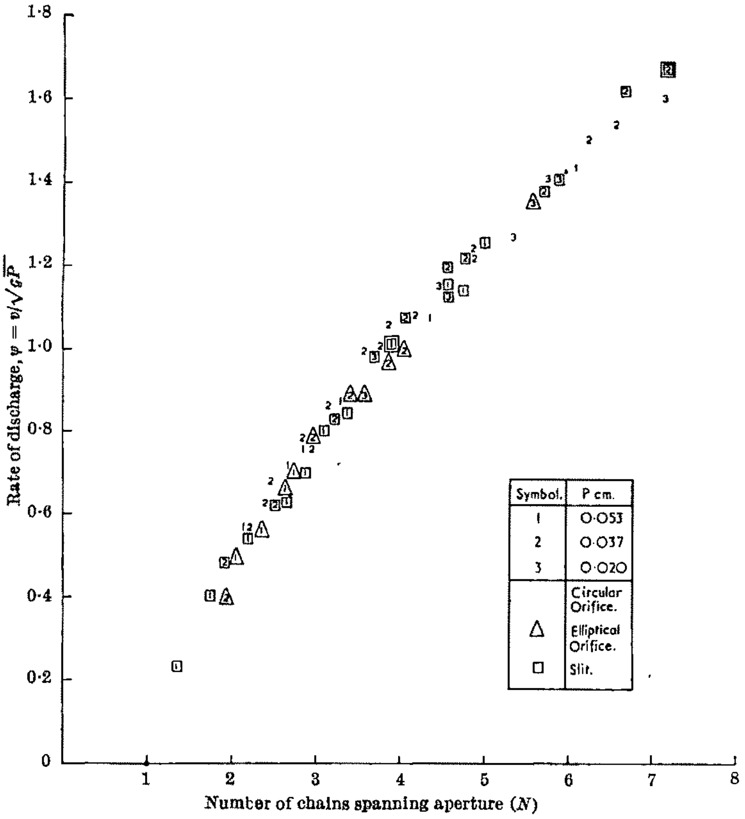

Fig. 1. Two- and three-dimensional flow of grains through apertures differing in shape and size

Further details and results for other materials and for flow from narrow vessels are given in a paper to be published elsewhere.

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Observations of the Pacific Equatorial Undercurrent

We have succeeded in measuring the flow of the Pacific Equatorial Undercurrent first described by Cromwell, Montgomery and Stroup[1]. Taut-wire buoys[2] were anchored in 2,300 fathoms as reference points. Measurements at different depths were made by suspending a modified Roberts current meter[3] from a drifting ship. A vibrotron pressure element was used to give the depth of the meter, and the drift of the ship relative to the anchored buoy was measured by radar. To define the bottom of the undercurrent four measurements were made with Swallow type neutral buoyant floats[4]. These measurements were the principal object of the Dolphin Expedition March 27–June 10, 1958, one of the special cruises of the International Geophysical Year oceanographic programme.

Five buoys were laid on long. 140° W. at latitudes 2° N., 1° N., 0°, 1° S. and 2° S. Measurements were made from two ships, *Horizon* of the Scripps Institution of Oceanography, University of California, and *Hugh M. Smith* of the Pacific Oceanic Fisheries Investigation, U.S. Fish and Wildlife Service. The equator station was monitored by one ship during April 6–28. The second ship made measurements at the other four buoys in rotation.

On the second half the expedition *Horizon* made measurements with the Roberts meter at 180-mile intervals along the equator from long. 137° W. to 89° W. For these measurements the reference buoy was a free-floating parachute drogue[5] with the parachute suspended at 1,000 m. Parachutes at this depth were occasionally used for reference at long. 140° W. and their motion with respect to the anchored buoys was about 0·2 knots.

The Undercurrent is an east-flowing current centred at the equator just below the west-flowing South Equatorial Current. Measurements at long. 140° W. indicate a transport of the order of 30 million cubic metres a second or about the same as the transport of the Florida Current. Measurements along the current indicate that it is at least 3,500 miles long.

At long. 140° W. the Undercurrent is symmetrical about the equator. During the 22-day observational period the highest velocities toward the east were always recorded at the equator and at a depth of 100 ± 13 m. The velocities in this core were between two and three and a half knots. During this period the South Equatorial Current was flowing westward at speeds between half a knot and one and a half knots.

The top and bottom of the Undercurrent are at about 30 and 300 m. respectively for 0°, 140° W. The Swallow drogues indicate a small flow to the west between 500 and 700 m.

The Undercurrent becomes thinner and weaker on either side of the equator. At 2° N. and S. the average thickness was 30 m. and the average maximum velocity was 0·6 knots.

Measurements made along the equator showed no diminution in the core velocity between long. 140° and 95° W. At 92° W. (25 miles west of San Isabela Island in the Galapagos) the core velocity was 1·2 knots. At 89° W. (east of the Galapagos) the Undercurrent was missing. The depth of the core rose from 100 m. at 140° W. to 52 m. at 98° W., a slope of $1 \cdot 3 \times 10^{-5}$. Stations of 95° and 92° W. showed the core dipping down. It was at 92 m. at 92° W.

Three days after the completion of these measurements, Townsend Cromwell, who discovered the Pacific Equatorial Undercurrent in 1952 and gave it its present name, was killed in an aeroplane crash near Guadalajara, Mexico, on June 2, 1958, on his way to join another Scripps Institution oceanographic expedition at Acapulco. We would like to suggest that this current be called the Cromwell Current.

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Protein Synthesis as a Basis for Chloramphenicol-Resistance in *Staphylococcus aureus*

It has been established that chloramphenicol is a specific inhibitor of inducible enzyme formation and of protein synthesis in general[1]. The antibiotic does not exert its effect on protein synthesis by inhibition of amino-acid activation, by inhibition of peptide bond formation, or by inhibition of incorporation of amino-acids into cell-wall[2]. Pardee, Paigen and Prestidge[3] reported that ribonucleic acid synthesized in the presence of chloramphenicol possessed an electrophoretic mobility which differed from that of normal ribonucleic acid synthesized in the absence of the antibiotic. It was later found by Neidhardt and Gros[4] that this altered ribonucleic acid was unstable and was rapidly degraded in the absence of chloramphenicol. These observations have prompted the suggestion by Gale[5] that "chloramphenicol alters, or in some way interferes with the function of the ribonucleic acid component concerned in amino-acid incorporation".

Two mechanisms of resistance to chloramphenicol have previously been observed. The enzyme 'chloramphenicol reductase' has been related to resistance of *Escherichia coli*[6] and a decreased permeability to chloramphenicol was noted by Kushner[7] in a strain of *Pseudomonas aeruginosa* which was resistant to the antibiotic.

Evidence has recently been obtained in this laboratory which indicates that a third mechanism of resistance is operative in *Staphylococcus aureus*. It has been found that both whole cells and cell-free preparations of a resistant strain are capable of forming inducible enzymes in the presence of a concentration of chloramphenicol which causes complete inhibition of the formation of enzyme in a sensitive strain.

Two strains of *Staph. aureus*, which have been described previously[8], were used throughout the study. The sensitive organism (strain *S*) was inhibited by 5 μgm. chloramphenicol per ml. and the resistant organism was capable of growing in the presence of 500 μgm. chloramphenicol per ml. The effect of chloramphenicol on formation of the two inducible enzymes, nitrate reductase and β-galactosidase, has been determined using procedures for induction and assay of the two enzymes which have been described previously[9]. The methods of Gale and Folkes[10] were used in experiments involving cells irradiated with ultrasonic waves.

The effect of chloramphenicol on induction of both enzymes in whole cells of strains *S* and *R* is shown in Table 1. In this experiment, the effect of adding 10 μgm. chloramphenicol per ml. to the system at zero time and at 2 and 4 hr. after the start of induction is compared. Addition of chloramphenicol at zero time results in a marked inhibition of the formation of enzyme in strain *S*; at 6 hr. the amount of β-galactosidase is only 12 per cent of that formed in the absence of the antibiotic. A similar inhibition is noted in the case of nitrate reductase. With strain *R*, however, addition of 10 μgm. chloramphenicol per ml. at zero time has no effect on the formation of enzyme. Another noteworthy effect is that obtained when chloramphenicol is added to the system after induction has proceeded for 2–4 hr. It is seen that this procedure results in an immediate cessation of

Table 1. EFFECT OF CHLORAMPHENICOL (CM) ON ENZYME INDUCTION IN *Staphylococcus aureus*, STRAINS *S* AND *R*

Time*	No CM added		10 μgm. CM/ml. added at zero time		10 μgm. CM/ml. added at 2 hr.		10 μgm. CM/ml. added at 4 hr.	
	S	*R*	*S*	*R*	*S*	*R*	*S*	*R*
	β-Galactosidase							
2 hr.	0·89†	3·9	0·35	2·9	0·82	5·3	1·02	5·5
4 hr.	5·6	9·4	0·55	9·4	0·9	11·1	5·6	12·7
6 hr.	6·6	10·6	0·77	12·3	1·0	13·3	5·1	13·9
	Nitrate reductase							
2 hr.	1·48‡	2·48	0·58	6·48	0·18	6·64	0·82	8·24
4 hr.	4·0	3·82	0	3·2	0·94	4·64	4·6	7·44
6 hr.	4·8	2·8	0·34	8·1	0	5·3	2·4	7·3

* Time, in hours, after start of induction.

† μMoles of *o*-nitrophenyl-β-D-galactoside hydrolysed per mgm. cells per 30 min.

‡ μMoles of nitrite produced per mgm. cells per 30 min.

Table 2. Effect of Chloramphenicol (CM) on Induction of Nitrate Reductase in Sonicated Cells

Time (min.)	No CM	1 μgm. CM/ml.	2 μgm. CM/ml.	3 μgm. CM/ml.	4 μgm. CM/ml.
			Strain *S*		
45	0·04*	0·03	0·01	0	0
90	0·06	0·04	0	0	0
135	0·63	0·26	0·1	0·05	0·02
180	2·41	1·03	0·47	0·24	0·08
			Strain *R*		
45	0·2	0·2	0·3	0·2	0
90	0·62	0·27	0·27	0·27	0·3
135	0·66	0·16	0·49	0·69	0·6
180	1·53	1·13	1·27	1·37	1·23

* μMoles nitrite produced per mgm. sonicate per 30 min.

the formation of enzyme by strain *S*, which persists throughout the course of the experiment. On the other hand, addition of 10 μgm. chloramphenicol per ml. to strain *R* after synthesis has started does not result in inhibition.

In order to determine whether the results obtained with whole cells were due to a resistant protein-synthesis mechanism or to decreased permeability of strain *R* to chloramphenicol, an inhibition experiment was performed using cells which had been subjected to ultrasonic disintegration in a 10-kc./s. 'Raytheon' oscillator. The viable count of the suspension after sonication was 3×10^6 cells per ml. compared with 9×10^9 cells per ml. before sonication. These disrupted suspensions were fully capable of forming enzyme. It may be seen (Table 2) that, here again, strain *R* is capable of forming enzyme in the presence of a concentration of chloramphenicol which completely inhibits the formation of enzyme in strain *S*. From these results it is concluded that permeability is not the main source of resistance in this organism, but rather that some alteration has occurred in strain *R* which makes protein synthesis less susceptible to the inhibitory effect of the antibiotic. Although the nature of the altered mechanism of synthesis has not been determined, certain experiments have been performed which give some insight into the nature of the resistance. First, it has been found that growing strain *R* in the presence of chloramphenicol or pre-incubating cells in the presence of the antibiotic prior to induction does not increase subsequent resistance to it in terms of protein synthesis. It would appear, therefore, that resistance is a stable characteristic of the cells and does not depend upon the presence of the antibiotic. It has also been found that cells which have been pre-incubated in the induction medium in the presence of chloramphenicol and inducers (nitrate and galactose), and then washed and resuspended in induction medium plus inducers, do not form enzyme at a faster rate than cells which have not been pre-incubated. This would indicate that chloramphenicol exerts its inhibitory effect by interfering with normal ribonucleic acid function as suggested by Gale[5], and the ribonucleic acid formed in the presence of chloramphenicol is not available for subsequent protein formation. These results would also support those of Ben-Ishai[11], who found that preformed ribonucleic acid did not function in subsequent protein synthesis.

Two features of the results obtained should be mentioned. First, with both strains *S* and *R*, sonicated cells are more susceptible to chloramphenicol than whole cells, indicating that a permeability barrier of sorts does exist. However, this barrier is no more pronounced in strain *R* than in strain *S*, since the quantitative difference in the concentration of chloramphenicol required for inhibition of the formation of enzyme in whole cells and in sonicates is no greater in strain *R* than in strain *S*. Secondly, the concentration of chloramphenicol required to inhibit formation of enzyme is much less than that required for inhibition of growth. This dichotomy is probably due to the difference in time intervals used in induction experiments and in growth experiments. For example, in the experiments shown here six hours was the maximum time of observation. In growth experiments, particularly those involving high concentrations of chloramphenicol, the maximum time interval is often in the range of 150–200 hr. It is probable that the concentrations of chloramphenicol required to inhibit enzyme synthesis would approach that required for inhibition of growth if induction experiments could be carried out for several days. For this reason, a direct correlation between resistance in terms of growth and resistance in terms of protein synthesis, must await experiments using continuous cultivation of cells in a chemostat.

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Permeabilizing Effects of Heparin and Heparin-like Substances

At a concentration of 0·001 per cent (w/v), heparin provokes liberation of the clearing factor from isolated perfused rabbit heart[1]. Desulphurated α-heparin and β-heparin have a similar activity, but chondroitinsulphuric acid and hyaluronic acids do not, in spite of their great chemical similarity to the three active substances[2]. Furthermore[3–5], heparin at 0·4 gm. per cent (w/v) induces an obvious diastolizing effect on a Straub preparation of isolated frog heart. Such cardiac diastolization can also be obtained by desulphurated heparin and by β-heparin at the same concentration, but not by chondroitinsulphuric acid or hyaluronic acid; only the action of β-heparin is irreversible. Diastolization is completely abolished if an over-dosage of 12 mgm. per cent of calcium ions is added to the Ringer solution.

These effects can be tentatively interpreted as an increase of permeability, at the level of cell membranes, perhaps due to removal of calcium.

In order to confirm such a hypothesis experiments have been performed on the outflow of rubidium-86 from the isolated diaphragm of albino rats.

Preliminary observations by Marro in collaboration with Hashish, made in the Zoophysiological Laboratory of Copenhagen under the direction of Prof. Ussing, seem to show a change in the outflow curve of the labelled ion, even at very low concentrations of heparin ('Eparina Novo' in ampoules).

Other experiments carried out with the same method[6] [7] in our laboratories, but with 'Boots' heparin (sodium heparin 110·9 T.U./mgm.), showed the same effect, only at higher concentrations.

The samples of liquids were tested for radioactivity using a Geiger counter for liquids (type *M* 6, 20th Century Electronics).

Three groups of experiments were performed at 38° C., each on five muscles: a control group; a second group in which 70 min. after washing had started the Krebs solution was replaced by another containing heparin at a concentration of 0·05 per cent (w/v); and a third group in which, always after the same lapse of time, Krebs solution was replaced by another in which the calcium ion concentration was reduced to two-thirds of that in normal Krebs solution.

Fig. 1 shows the average results obtained from the three experimental groups, in the same order as above mentioned, from left to right; the relative counts/min. are shown on a logarithmic scale. Both the addition of heparin and the reduction of calcium ion concentration seem to modify the kinetics of exchange of rubidium-86, increasing its outflow; the modification induced by heparin appears to be quantitatively greater than that following partial removal of calcium ions.

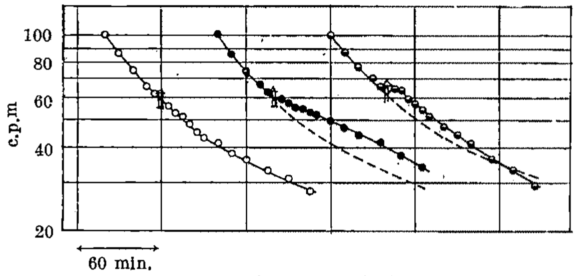

Fig. 1. For key see text.

Therefore, it seems reasonable to conclude that in rubidium exchange heparin exerts a permeabilizing action; this effect may perhaps be related to a removal of calcium ions, since it can be, at least partially, reproduced by a decrease in calcium content of the perfusing solution.

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Isolation from Human Blood of a New Substance associated with Fat Transport Activity

Fat absorption was studied on a number of patients with various neoplasms. In all cases, after ingestion of iodine-131-labelled triolein dissolved in olive oil, the excretion of the labelled fat and its metabolites was followed by scintillation counting. The rate of absorption into the blood stream, and the state and distribution of the absorbed substances were investigated as follows.

The activity of aliquots of blood was measured at appropriate intervals after the injestion, and relatively larger aliquots (20 ml.) were drawn for chemical examination near the peaks of activity (2 and 4 hr.) and also after 6 hr.; at this time there was a more or less pronounced decrease in the amounts of labelled compounds in the blood. The proteins in the pooled blood (60 ml.) were precipitated with a mixture of methylal and methanol (4 : 1 to 15 vol. blood); this protein precipitant[1] [2] was used in preference to the usual trichloracetic acid because it affords milder conditions of treatment (neutral reaction at room temperature).

The methylal–methanol extract contained 75–85 per cent of the whole blood activity. This includes 7–10 per cent of activity present as inorganic iodide. After evaporation to dryness *in vacuo* in the absence of oxygen, the residue was extracted with petroleum ether (60–80°), and this extract contained practically the whole activity in about 200 mgm. of fatty material. The inorganic iodide was either removed from the extract ('De-acidite F F'; Cl-form) before chromatography, or the solution was submitted without 'De-acidite' treatment to adsorption chromatography on a silica–petroleum ether column (20 mm. × 600 mm.; 80 gm. silica). The adsorbed substance was developed by gradient elution with petroleum ether – ether – methanol; the shapes of the eluent and mixing chambers were chosen in such a way as to give a linear gradient with an angle of about 40°; the start of the gradient was delayed by developing with the pure, less polar solvent until 5 × 10 ml. fractions have passed through the column.

There were two very pronounced and sharp peaks of activity in the eluted fractions: first in order of emergence, a smaller one containing about 10 per cent of the activity of the original solution, and then a second peak containing about 60 per cent of the total activity adsorbed on to the column.

The material forming the first peak has as yet not been extensively investigated; it contains, however, fatty acids and cholesterol, and is probably largely a cholesterol oleate.

The substance contained in the second peak appears to be homogeneous. After hydrolysis it contains free fatty acids, phosphate, choline, and eight to nine amino-acids: alanine, arginine, cysteine, glutamic acid, glycine, leucine, serine, threonine, and valine. However, although the one-dimensional paper chromatograms were run with markers, the results so far obtained are of a preliminary character, and work on the identification and quantitative estimation of these amino-acids is proceeding.

Solutions of the unhydrolysed substance do not contain detectable amounts of inorganic phosphate, free amino-acids, fatty acids or choline. On paper electrophoresis at *p*H 5·0 and at 8·6 the substance remains homogeneous on the origin, and no moving components could be detected on the paper in either direction of the current. On paper chromatography in several solvent systems the substance moves as a homogeneous spot.

Quantitative determinations of choline[3], phosphorus[4], and amino-acid nitrogen[5] point to the relation 1 : 3 : nono- or deca-peptide. The substance is probably a phosphorylated pepto-lecithine-like compound; we have no indication yet where the two additional phosphoric acid residues might be.

In four of the cases examined, this substance contained the greatest amount of activity (about 60 per cent. However, in the case of one patient, this substance though present in the usual quantity, contained very little activity. In this case 59·6 per cent of the activity was contained in another fraction, which on analysis proved to contain a similar peptide, fatty acids and phosphorus but no choline. The reason for this is not clear and work is continuing in this direction.

It is interesting to speculate about the possible relation of this pepto-lecithine-like substance with the peptide of the lipid mobilizing factor described in the literature[6]. In fact, the two-dimensional amino-acid chromatograms of the hydrolysates of our substance show great similarity to those of the fat mobilizing factor found in human urine[7] (Dr. Ivor Smith, private communication).

We wish to thank Sir Charles Dodds and Prof. J. E. Roberts for their interest and support. Our thanks are also due to Mr. C. F. M. Rose and our medical officer, Dr. K. M. Jones, for their invaluable help.

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Movements of Potassium in Rabbit Auricles

Movements of potassium-42 have been measured in beating right and quiescent left rabbit auricles at 37° C., immersed in modified Krebs saline containing 5·2 mM potassium, and gassed with an oxygen/carbon dioxide mixture to a pH of 7·35 [1]. Efflux was measured by counting the tissue directly in a bath of 10 ml. capacity, through which flowed inactive medium, after a period of immersion in active medium[1,2]. Influx measurements were made in the same apparatus in the presence of active medium. Although the contribution of the medium to the observed counting rate was high throughout, and the total increase in count was never more than twofold, reproducible increments in tissue count were obtained for about 120 min. Retropolation to zero time of the counts between 5 and 24 min. of efflux, plotted semi-logarithmically, allowed the true bath background to be obtained, free from the effects of displacement of medium and absorption of counts by the tissue. In the absence of tissue, more than 99·5 per cent of the active medium was washed out of the bath within 3 min., on changing to inactive medium. The method of measuring influx offered the advantage that influx and efflux could be followed in the same tissue, and that the tissue could be stimulated during the course of influx measurement.

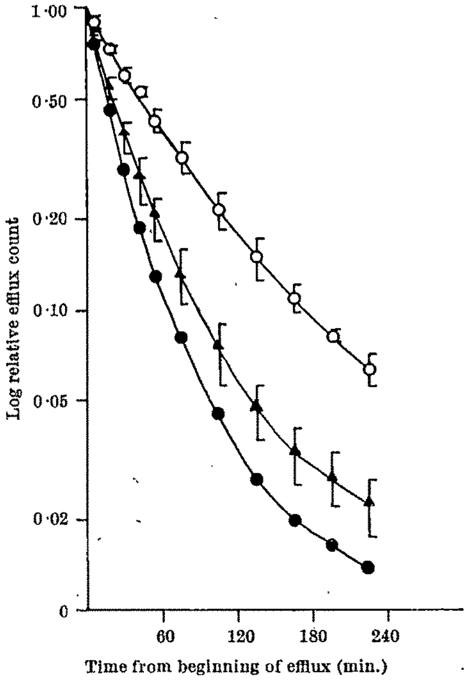

Fig. 1. Efflux of potassium-42 from rabbit auricles; ○, efflux from non-beating left auricles; ▲, efflux from right auricles beating at 170–210/min.; ●, efflux from left auricle stimulated electrically at 210/min. Range marks, standard error of three right and two left auricles. The curve of non-beating left auricles is significantly different from those of beating right auricles ($P < 0·01$), and stimulated left auricle ($P < 0·05$)

Neither influx nor efflux of tracer followed a strictly exponential course. The initial influx rate-constant, k_i, was always smaller than the initial efflux rate-constant, k_e, measured after 40 min. of influx. Both values, especially in right auricles, decreased with time. The ratio of initial k_i to k_e was significantly smaller ($P < 0·01$) in right ($0·723 \pm 0·042$; standard error of 6 determinations), than left auricles ($0·892 \pm 0·026$; standard error of 6 determinations). Losses of potassium, which were slight (about 2 per cent/hr.), and equal for right and left auricles, do not provide a satisfactory explanation for these differences. However, the results may be due to an inhomogeneity of the auricle potassium, which is greater in right than left auricles[1]. When a left auricle was stimulated electrically to beat at the same rate as spontaneously beating right auricles (about 200 per min.), its curves of efflux (Fig. 1) and influx closely resembled those of right auricles. The difference in the shape of curves of right and left auricles appears to depend, therefore, on the activity of the tissue, and results from incomplete equilibration of the potassium which is exchanged at each beat with the rest of the cell potassium, rather than on the presence in the right auricle of special cells which exchange their potassium more rapidly. This is supported by the observation that right auricles, after treatment with some drugs in concentrations which just inhibited mechanical activity (for example, 8×10^{-6} M quinidine), had influx and efflux curves, and a ratio of initial k_i to k_e

(0·912 ± 0·018; 4 determinations), which were like those of left auricles. It follows that computation of potassium fluxes, especially in right auricles or beating auricle pairs[1,3], using the model based on single exponential exchange[2], will give results which are misleading.

Cocaine, quinidine and atropine decreased the inward and outward movements of potassium-42 both in beating right and quiescent left auricles. These drugs, acting on initially beating right auricles, had log molar dose-response curves which were rectilinear and parallel; cocaine was approximately equal in potency to quinidine, and atropine had about one-eighth of this potency. These results are consistent with the hypothesis that the drugs decrease the permeability of the cell membrane to potassium ions[4].

I am indebted to Prof. M. Weatherall for his advice and guidance in this work.

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Substances depressing the Phagocytic Activity of the Reticulo-Endothelial System

In previous publications[1-3] we have reported the effect of various steroids, stilbenes and aliphatic hydrocarbons on the phagocytic activity of the reticulo-endothelial system, intimating that the strongest stimulants possessed high œstrogenicity. The present communication records the relative effect on phagocytic activity of the substances which we have found to depress the reticulo-endothelial macrophages.

The experiments were carried out on 125 male white mice (*T.O.* Swiss strain) of 20–30 gm. body-weight. Five of the animals were used to assess the effect of each substance on the phagocytic activity of the reticulo-endothelial system, each animal receiving one subcutaneous injection of 0·5 mgm. of each substance daily for six days. The phagocytic activity was then measured on the eighth day by the rate of disappearance of a known amount of carbon from the circulating blood[4], the procedure being as described in a recent communication[2]. The total body phagocytic activity or phagocytic index is denoted as previously by the symbol *K*.

The results are shown in Table 1. The substances in Group 1 were administered subcutaneously in aqueous solution. For this group 25 animals were used as controls. They were given carbon only and showed an average phagocytic index or *K*-value of 26.

The substances in Group II were each given in 0·05 ml. of arachis oil. For this group 25 animals were used as controls. Each received one subcutaneous injection of 0·05 ml. arachis oil daily for six days, then carbon on the eighth day. These animals showed an average phagocytic index or *K*-value of 13.

Compared with the control values, the results show that cortisone acetate, prednisone, prednisolone and 4-hydroxytetraphenylmethane are strong depressants of phagocytic activity, whereas the other substances shown in Table 1 are mildly depressant. None o the substances used possesses high œstrogenic activity

Table 1. Substances which depress the Phagocytic Activit of the Reticulo-Endothelial System

	Substance administered	Phagocytic index (*K* value)
Group I Administered in aqueous solution, subcutaneously	Cortisone	7
	Prednisone	8
	Prednisolone	8
Control values for 25 untreated animals		26
Group II Administered in arachis oil, subcutaneously	4-Hydroxytetraphenylmethane	8
	Sitosterol	10
	Androstalone	10
	Deoxycortone acetate	10
	Ergosterol	10
	1-*p*-Hydroxyphenyl-1 : 1-diphenyl propane	10
	Lanosterol	11
	Cholesterol	11
	Stilbene	11
	4 : 4′-Dihydroxydibenzyl	11
	4 : 4′-Dihydroxystilbene	11
	3-(*p*-Hydroxyphenyl)-3-phenyl-*n*-pentane	11
Control values for 25 animals which received 0·05 ml. arachis oil subcutaneously once daily for 6 days		13

We are indebted to Sir Charles Dodds for generously supplying the majority of these substances.

We also gratefully acknowledge assistance from th Central Research Fund of the University of London

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Stomoxys sp. on Cattle in Uganda

It is common practice in Uganda to house cattl during the hottest part of the day, between 11 a.m and 3 p.m. (approximately 10 a.m. to 2 p.m. sun time) primarily to protect them from irritation caused b the biting fly *Stomoxys* sp. Although no factua evidence is available, it is generally assumed tha where cattle are left out continuously much of th observed loss of condition can be ascribed to thi annoyance. Were this housing unnecessary it migh be possible to avoid, not only the added expense, bu also the inconvenience caused by extra herding o extensive ranching systems.

The predominant species at the Cotton Researc Station, Namulonge, is *S. nigra* Macq. and, fro numbers of adults recorded on tethered bait cattle a diurnal cycle of activity is apparent (see Table 1) with minimum activity occurring between 11 a.m. and 2 p.m.

Regression analyses on the number of feeding adult flies on observed climatic factors indicate that saturation deficit accounts for the greatest part of the total variation of *Stomoxys* populations ($R^2 =$

Table 1. Mean Number of *Stomoxys* recorded on Two Bait Co on 15 Occasions between 17.3.58 and 5.5.58

Local time	a.m. 7	8	9	10	11	12	p.m. 1	2	3	4	5	6
No. *Stomoxys*	12·1	19·5	18·9	16·7	14·5	13·1	14·4	15·3	18·7	19·2	17·2	18

−0·435). Successive generations follow a 20–30-day interval with increased emergence preceding periods of abundant rainfall during the larval period. This confirms other work on optimum breeding conditions[1].

Adult *Stomoxys* are readily caught in modified tsetse fly traps[2] when placed up to 10 yards from cattle. The efficiency of these traps decreases as the distance increases so that at 30 yards very few flies are trapped.

The grazing habits of cattle do not appear to be seriously restricted during the periods of greatest activity of the flies since at these periods grazing activity is also near maximum (see Table 2).

Table 2. MEAN PERCENTAGE OF CATTLE GRAZING BETWEEN DAWN AND DUSK DURING MONTHS APRIL AND MAY 1958

Local time	a.m. 7	8	9	10	11	12	p.m. 1	2	3	4	5	6	7
Percentage grazing	19	66	60	38	18	48	18	50	34	40	66	79	96

After three months of observation on two herds of young bullocks, one herd which is housed during the period mentioned shows a slight increase in live-weight gain over the herd left out continuously. The increase, however, is certainly not commensurate with the inconvenience and additional effort required for midday housing.

This investigation is being continued and in due course will be published elsewhere.

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Intracellular Particles of Locust Fat Body

THE enzyme activities of insect mitochondrial preparations have been described in a number of papers[1–3]. I have observed that certain particle-bound enzymes in homogenates of the fat body of the desert locust (*Schistocerca gregaria* Forsk.) can be separated partially by differential centrifuging, and conclude that there are (at least) two distinct types of particles which resemble mammalian liver mitochondria and microsomes.

The tissue was taken from fifth instar nymphs on the fifth or sixth day of the eight-day stadium, freed of air sacs, washed once in cold water, drained on filter paper, and homogenized in 0·25 *M* sucrose solution at about 150 mgm. wet weight/ml.

The homogenate was centrifuged for 2 min. at about 600*g*, the upper layer of fat removed by suction, and the supernatant whole suspension decanted from the sediment of debris (and probably nuclei). The mitochondria were then sedimented from this suspension at 0° C. by spinning for 5 min. at 4,500*g*, and the supernatant carefully withdrawn and centrifuged at 14,000*g* for a further 30 min. at 0° C. The resulting clear supernatant was removed from the packed microsomes, and both particle fractions resuspended, without washing, in 0·25 *M* sucrose to the original volume of the whole suspension.

The whole suspension and the three fractions were tested for the following enzymes: (*a*) cytochrome oxidase (ref. 4, 2, 735); (*b*) fumarase (ref. 4, 1, 730); (*c*) Schradan-oxidizing enzyme, by rate of inhibition of endogenous phenyl esterase in the presence of supernatant or reduced triphosphopyridine nucleotide[5]; (*d*) aconitase, with citrate substrate (ref. 4, 1, 695); (*e*) isocitric dehydrogenase (ref. 4, 1, 699); and (*f*) phenyl esterase, by rate of liberation of *p*-nitrophenol from *p*-nitrophenyl acetate[6]. The results are expressed as percentages of the activity of the whole suspension in Table 1.

Table 1

Enzyme	Percentage activities		
	Mitochondria	Microsomes	Supernatant
Cytochrome oxidase	80	20	0
Fumarase	79	21	0
Schradan oxidizing	16	84	0
Aconitase	0	0	100
Isocitric dehydrogenase	0	0	100
Phenyl esterase	42	38	20

The mitochondrial fraction (sedimented at 4,500*g*) also contained some heavier particles which had none of the enzyme activities tested, but were distinguished by giving a red-brown colour with iodine and a positive Benedict's test only after incubation with saliva. They were presumed to consist of glycogen granules. They could be isolated by centrifuging a whole suspension at 14,000*g* for 30 min., when the sediment consisted of two clearly defined layers. The upper brown layer (mitochondria and microsomes) could be separated readily from the lower translucent grey one (glycogen-like material) by gently stirring with a small quantity of sucrose solution and decanting.

I am grateful to the Anti-Locust Research Centre for the locusts, and to Messrs. Fisons, Ltd., and the Agricultural Research Council for financial support.

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Microvilli of the Cells of the Human Adrenal Cortex

IN the course of an electron microscopic survey of the human adrenal cortex an interesting specialization of the cortical cell plasma membranes was noted. Human adrenal cortex was removed at operation, fixed in 1 per cent isotonic osmic acid, embedded in methacrylate, sectioned by the standard technique on a thermal advance microtome, and examined in a Philips *EM* 100 microscope. Using parallel thick sections stained (Wright–Giemsa) and the light microscope, the different zones and cell types were readily identified.

In many of the cells of the zona fasciculata and zona reticularis, the plasma membranes form a complex arrangement of microvilli which project into the intercellular space in contact with similar microvilli of neighbouring cells (Fig. 1). The microvilli are tubular—150–200 A. in diameter—visible as circular and longitudinal profiles, and bounded by an osmophil single membrane with, at the relatively low resolution employed, a structureless centre (Fig. 2). The prominence of the villi varies at different points on the

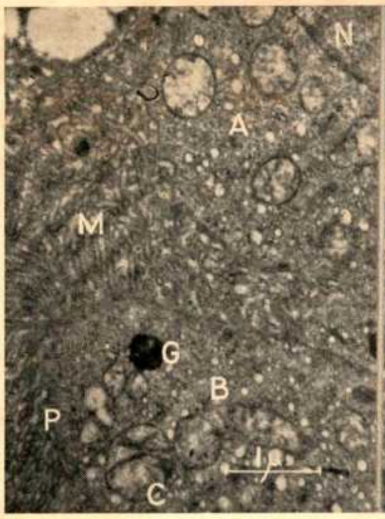

Fig. 1

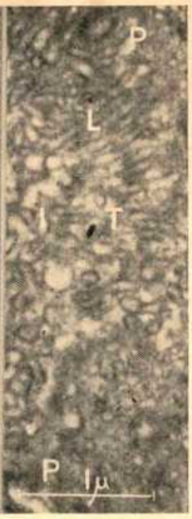

Fig. 2

Fig. 1. Section through zona reticularis of human adrenal. The intercellular space between cells *A* and *B* is occupied by microvilli *M*, which are clearly evaginations of the plasma membrane *P* of the cells. *N*, Nucleus; *C*, mitochondrion; *G*, lipid globule. (× 12,000)

Fig. 2. Section through microvilli cut in longitudinal (*L*) and transverse (*T*) section. *I*, Intercellular space; *P*, cell plasma membrane. (× 18,500)

cell surface; in the wide intercellular space at the junction of three or more cells the microvilli are longer and more numerous; where two cells are closely apposed the cell membrane tends to be smooth, while adjacent to blood sinuses it is merely imbricated (Fig. 3).

The cell processes of the human adrenal cortical cells are longer and more complex than similar processes described in the rat adrenal cortex[1] and in the parathyroid[2,3], and merit the description of microvilli, that is, something more than mere interdigitating extensions of cell membranes. Such structures are generally associated with the need for an increased absorptive surface; it seems likely that in the adrenal cortex that is also their function, and that they are in some way connected with the secretion of the steroid hormones.

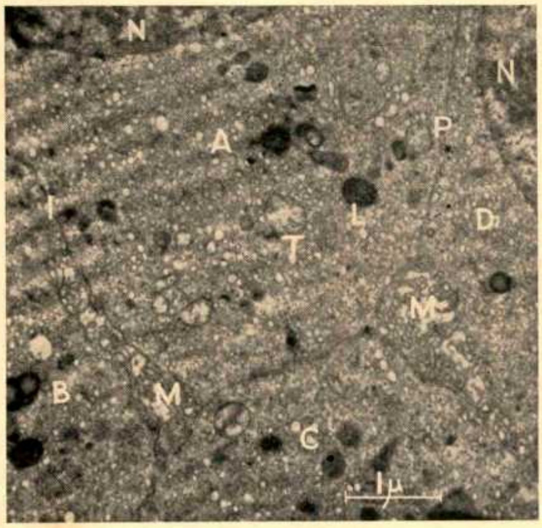

Fig. 3. Section through four cells (*A*, *B*, *C*, *D*) of zona reticularis. The plasma membranes are plane (*P*) or imbricated (*I*) where only two cells are in contiguity, but are thrown into microvilli (*M*) where the intercellular space is bigger. *N*, Nucleus; *T*, mitochondria; *L*, lipoid globules. (× 12,500)

Another characteristic of the human adrenal cortex is the clear distinction, at the electron microscopic level, between the cells of the zona reticularis and those of the zona fasciculata. The former contain relatively few lipoid granules, but larger and more numerous mitochondria as compared with those of the latter.

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Enteroviruses in the Pig

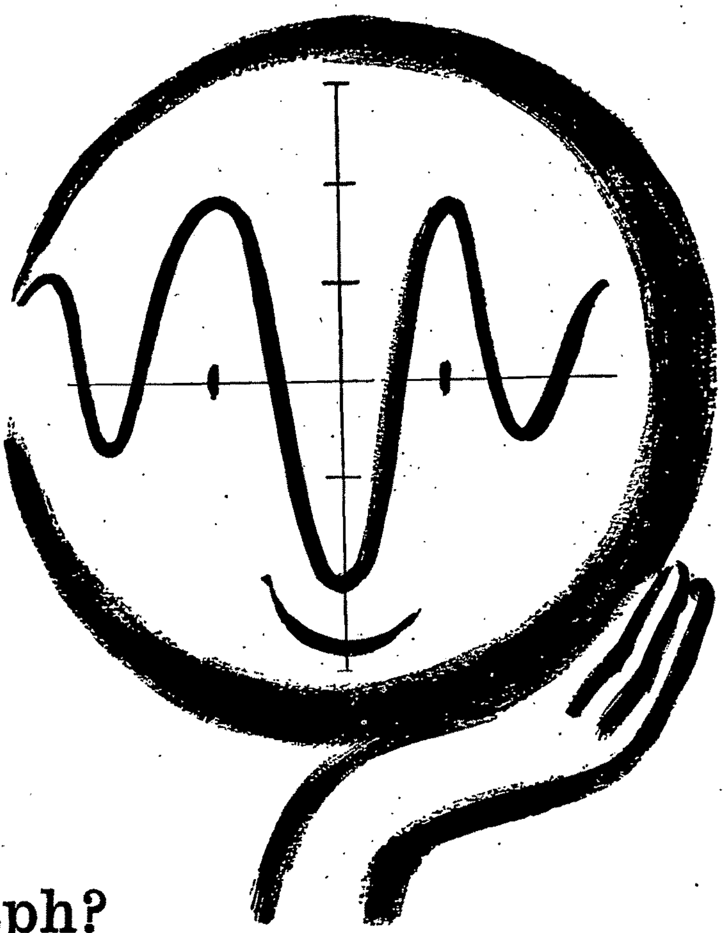
IN recent years, many viruses have been recovered from the alimentary tract of man and the term 'enteroviruses' has been proposed[1] as a group name for them. The enterovirus group comprises the three strains of poliomyelitis virus, the Coxsackie viruses and the Echo (enteric cytopathogenic human orphan) viruses. The Echoviruses have not yet been conclusively associated with specific clinical conditions and it is not at present possible to determine their exact significance as causes of disease in man. Using tissue culture techniques attempts are being made in this laboratory to determine whether viruses comparable to the human enteroviruses occur in the alimentary tract of pigs.

The tissue-cultures used have been stationary monolayer cultures prepared from renal cortical tissue of the pig by a modification of Bodian's trypsinization method[2] and grown in a medium consisting of calf serum (20 per cent) and lactalbumin hydrolysate (0·5 per cent) in Hank's balanced salt solution with antibiotics. Before inoculation, the growth medium has been replaced with a maintenance medium consisting of calf serum (5 per cent) and lactalbumin hydrolysate (0·5 per cent) in Earle's balanced salt solution with antibiotics.

From the first thirteen fæces samples examined three immunologically distinct cytopathogenic agents have been recovered. One of these agents was isolated from an outbreak of a disease clinically similar to Talfan disease[3] (Teschen disease or poliomyelitis suum). This agent was neutralized by antisera to Talfan disease, kindly supplied by Mr. J. T. Done.

Another agent, one which has been studied in some detail, was recovered from fæces collected from pigs in a herd in which enteritis was a severe problem.

This virus causes a cytopathogenic effect in pig kidney cells similar to that caused by poliomyelitis in human or simian kidney cultures. The effect appears 3–5 days after inoculation but the increase in virus titre precedes this by 24 hr. Titres are of the order of 10^5 tissue-culture *ID*50 per ml. of tissue-culture fluid. The virus will pass through 'Gradocol' membranes having an average pore diameter of 100 mμ, but not through membranes with an average pore diameter of 55 mμ; preliminary electron-microscope studies show a particle of diameter of the order of 35 mμ. The agent is resistant to ether; it is inactivated within 2 min. at 56° C., within 100 hr.



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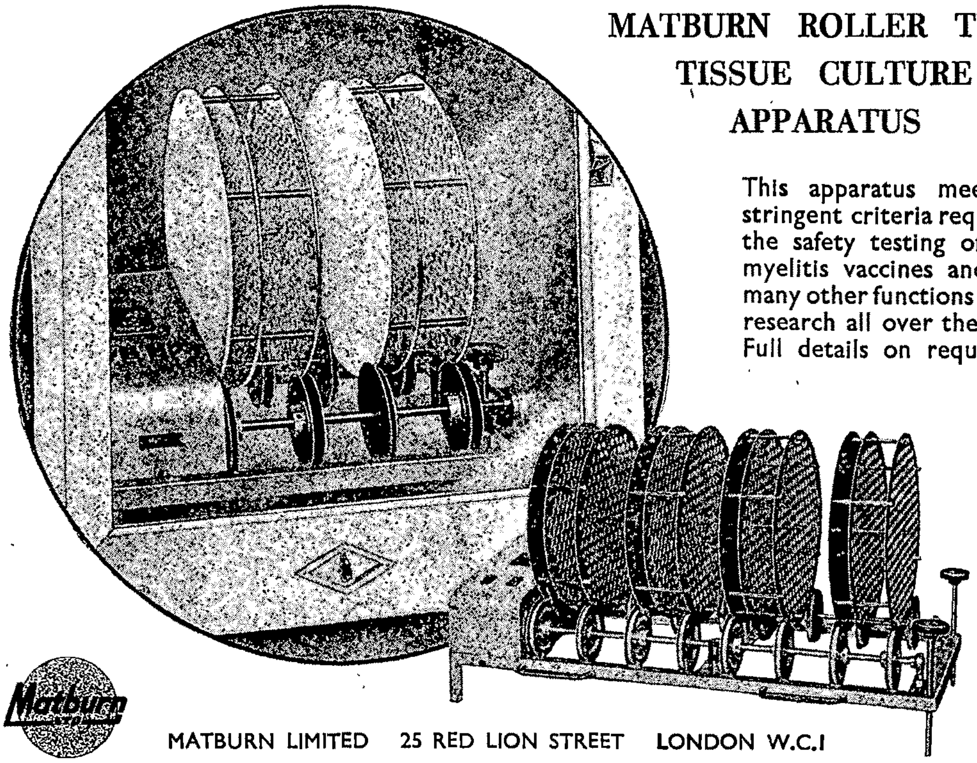

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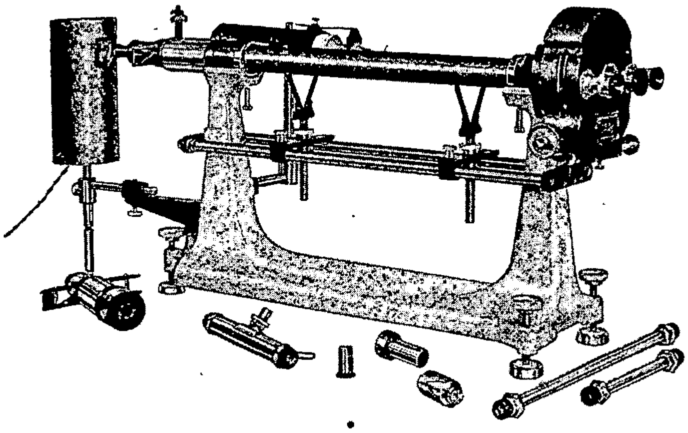

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at 37° C., but will survive more than three weeks at room temperature. It is easily preserved by storage at − 68° C. and can be successfully freeze-dried. Formaldehyde, at a concentration of 0·009 per cent, inactivates 90 per cent of the virus in 30–48 hr. Attempts to cause a cytopathogenic effect in bovine kidney and human epithelial cells (strain HeLa) have failed, as have attempts to adapt the virus to growth in embryonated hen's eggs.

Several attempts to infect pigs have been made with tissue-culture fluids containing virus. In all cases the experimental pigs were colostrum-deprived, 'disease-free' piglets obtained by hysterectomy following the methods of Young and Underdahl[4,5]. Various routes of inoculation were tried but the only clinical response obtained was a transient rise in temperature accompanied by a slight diarrhœa. Attempts to potentiate the response with cortisone were unsuccessful. No pathological changes were found on post-mortem examinations. The virus has been recovered from the fæces of these experimentally infected pigs, while sera from all of them showed an increase in neutralization index of more than 1,000-fold.

Studies on this virus are still in progress and will be reported in detail elsewhere.

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Light and Dormancy in Wild Oats (*Avena fatua* L.)

Recently, inhibitory effects of white light on germination of wild oats with natural dormancy[1,2] and with dormancy induced by previous immersion in water[3] have been reported. To test the effect of quality of light on the germination of wild oats, white light at 440 foot-candles was provided by tungsten plus standard cool white fluorescent lamps. Infra-red filters and coloured 'Cellophane' were used to isolate the blue, red and infra-red parts of the spectrum. The temperature in each Petri dish was 24·5 ± 0·5° C.

Table 1 shows that none of the light treatments inhibited germination of non-dormant wild oats or wild oats with dormancy broken by removing the hulls and then puncturing the seed coats. However, white, blue and infra-red radiation markedly inhibited germination of partially dormant wild oats. Seeds of the lettuce var. Grand Rapids (about which much is known regarding light sensitivity[4]) were also exposed to the same conditions for comparison. Blue and infra-red radiation strongly inhibited germination of the lettuce seeds whereas red and white caused slight stimulation. Although the latter increases were small they were found consistently. Thus, red light was without effect on wild oat germination but it stimulated lettuce seed germination. White light, on the other hand, was decidedly inhibitory to wild oats but not to lettuce.

Table 1. PERCENTAGE GERMINATION OF WILD OATS AND LETTUCE FIVE DAYS AFTER INHIBITION, EXPOSED TO WHITE, BLUE, RED AND INFRA-RED RADIATION AND DARKNESS. CONTINUOUS LIGHT SOURCE. TEMPERATURE, 24·5 ± 0·5° C.

Condition of seed sample	Quality and energy (gm. cal. cm.$^{-2}$ hr.$^{-1}$) of radiation White (440 f.c.)	Blue	Red	Infra-red	Darkness
Non-dormant wild oats	97·5	100	100	100	97·5
Dormant wild oats	28·0	14·0	60·0	8·0	66·0
Dormant wild oats—dehulled then pricked	100	100	100	100	100
Lettuce var. Grand Rapids	77·0	1·5	81·0	3·0	68·5

Similar results were obtained in other tests on wild oats conducted with white light ranging from 300 to 1,500 foot-candles and at temperatures between 20 and 25° C. The response was similar under either short or long days, or continuous light.

Little attention has been given to the effect of light on the germination of weed seeds under natural conditions. To study the effect of daylight on the germination of wild oats, partially dormant and non-dormant seeds were planted on the soil surface and at a depth of 1 in. in wooden flats. One set of flats was placed in a confined space in darkness and watered frequently to maintain high humidity at the soil surface. Other flats were placed outdoors in direct sunlight; in one treatment the air above the soil surface was kept moist by an intermittent mist spray (relative humidity not less than 95 per cent), in the other the soil surface was watered at the start and then left under prevailing natural conditions (control).

Table 2 shows that there was virtually complete germination of non-dormant seeds on the surface and at a depth of 1 in., both in sunlight and in darkness. In contrast, with the partially dormant seeds in light, there was only 10 per cent germination at the soil surface, whereas 65 per cent germinated at the 1-in. depth. That the inhibitory effect on the soil surface was due to light is shown by the fact that 55 per cent germination was obtained on the surface in the dark. (The lower germination of partially dormant seed at 1 in. in darkness was afterwards found to be due to excessive watering, which was inhibitory to germination below the surface; this does not alter the conclusion that light inhibited germination at the surface).

These experiments show that, under artificial conditions, white, blue and infra-red radiation inhibit germination of partially dormant wild oats. Under natural conditions, daylight inhibits the germination of partially dormant wild oats on the soil surface; cultivations that bury such seed may therefore favour increased germination. Recent field tests have shown that, when autumn tillage was practised, wild oats

Table 2. PERCENTAGE GERMINATION OF DORMANT AND NON-DORMANT WILD OATS, PLANTED ON SOIL SURFACE AND AT 1-IN. DEPTH. PLANTED SEPTEMBER 15, 1957; DATA RECORDED, SEPTEMBER 23, 1957

Condition of seed sample	Depth planted	Darkness: High relative humidity*	Normal daylight: High relative humidity*	Normal daylight: Control
Non-dormant	Surface	95	98	85
	1 in.	98	100	97
Dormant	Surface	55	10	1
	1 in.	23	65	64

* High relative humidity = not less than 95 per cent.

germinated earlier and in greater numbers the following spring[5].

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Effect of Gibberellic Acid on Corolla Size

IN a previous communication[1] I reported that emasculation of *Glechoma hederacea* flower buds resulted in a reduction in corolla size similar to that found in naturally occurring female flowers, and I suggested that the anthers produced a hormone causing enlargement of the corolla. An attempt to replace this by the application of β-indolylacetic acid to emasculated buds was ineffective—low concentrations having no effect and high concentrations (500 and 1,000 p.p.m.) causing inhibition of corolla growth.

This year I have tested α-naphthaleneacetic acid, 2 : 3 : 5-tri-iodobenzoic acid and L-proline (cf. ref. 2), and found that they did not affect corolla size except at high concentrations, when they were inhibitory.

Dr. S. Housley suggested the use of gibberellic acid and this proved effective. When applied in aqueous solution to emasculated buds it restored the size of the corolla to that of intact flowers (the results of one experiment are given in Table 1). A small increase also resulted from treatment of intact hermaphrodite buds with gibberellic acid.

Table 1. EFFECT OF GIBBERELLIC ACID (10 P.P.M.) ON EMASCULATED AND INTACT HERMAPHRODITE FLOWER BUDS OF *Glechoma hederacea*

Treatment	No. of flowers measured	Mean length of mature corollas (mm.)
Emasculated. Gibberellic acid inserted	8	19·6
Emasculated. Distilled water inserted	12	15·9
Intact. Gibberellic acid inserted	14	21·3
Intact. Distilled water inserted	14	19·4

Treatment of natural female flowers caused a striking enlargement of the corolla, producing flowers of about the same length as intact hermaphrodites (Table 2).

Table 2. EFFECT OF GIBBERELLIC ACID (10 P.P.M.) ON NATURAL FEMALE FLOWER BUDS OF *Glechoma hederacea*

Treatment	No. of flowers measured	Mean length of mature corollas (mm.)
Gibberellic acid inserted	12	19·1
Distilled water inserted	12	13·4

The situation appears to be comparable with that in dwarf peas, which are converted into tall peas by gibberellic acid but are unaffected by auxin alone[3].

The effect of emasculation and its reversal by gibberellic acid may be general phenomena. I have obtained results from *Geranium anemonifolium* similar to those from *Glechoma*.

Full details of the work will be published elsewhere.

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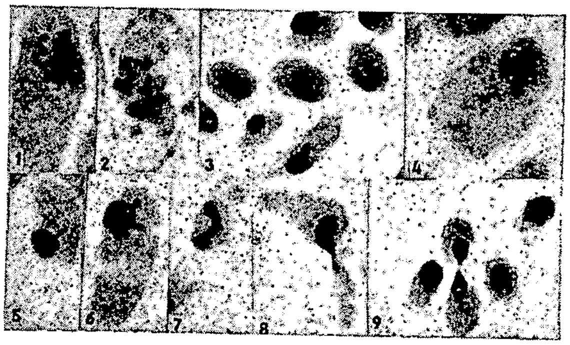
Kinetics of Mitosis in Yeasts

WHILE differences of opinion still exist among yeast cytologists concerning the real significance of the vacuole and the chromosome number of different yeast species, it is clear from the work of De Lamater[1], Lietz[2], Winge and Roberts[3], Lindegren *et al.*[4] and McClary *et al.*[5] that (*a*) during division the yeast nucleus resolves into chromosomes which can be identified by suitable techniques; (*b*) the nuclear membrane persists throughout the division cycle, whereas in higher organisms the membrane disappears in the prophase and reforms in telophase; and (*c*) intra-nuclear mitosis is followed by a process of nuclear separation and movement into the daughter cell which simulates amitosis. Doubt whether nuclear division is amitotic[6,7] could thus arise when no distinction is made between the nuclear division proper and the transport of the daughter nucleus into the bud. We have studied the nuclear cytology of the vegetative diplophase of *Saccharomyces cerevisiae*, *Zygosaccharomyces priorianus* and *Schizosaccharomyces pombe*, using a new technique[8], and the course of mitosis and the mode of separation of daughter nuclei observed by us are described here.

Division phase. At the onset of mitosis the nucleus is resolved into chromosomes, and configurations resembling the prophase and metaphase chromosomes of other organisms could be seen in squash preparations (Figs. 1 and 2). The exact chromosome number



Figs. 1–9. Giemsa preparations of mitotic stages in *S. cerevisiae*. (1) Prophase. (2) Metaphase. (3) End of intranuclear mitosis. A double structure in some nuclei and single and divided centrosomes are seen. One cell with the smaller nucleus has apparently not yet entered mitosis. (4) A nucleus with a single centrosome. (5) and (6) Beginning of the separation of the divided halves of the nucleus. Two centrosomes are seen. (7) A near dumbbell configuration. (8) One nucleus passing into the bud. The centrosome is seen entering the bud first. (9) Final stage in the separation of nuclei

is, however, not clear. We have seen eight chromosomes (Fig. 2) in some, but not in all cells. The difficulty in getting consistent pictures of chromosomes arises largely from the persistence of the nuclear membrane. Metaphase is followed by anaphase, in which the two chromatids of each chromosome seem to go to opposite poles ; telophase then sets in. We have never observed directly anaphase and telophase within the nuclear membrane, but the pattern of staining and the appearance of unstained regions within the nucleus suggest that these stages follow metaphase. It also appears that the telophase is prolonged, since nuclei appearing double are commonly seen (Fig. 3). A single centrosome is also seen at this stage (Fig. 4).

Separation phase. The centrosome divides into two at the end of the intra-nuclear mitosis. This is followed by the appearance of a small median constriction in the nuclear membrane between the centrosomes (Fig. 5). This constriction proceeds by furrowing and leads to a partial division of the divided nucleus. The extension of such furrowing results in the two partially divided halves of the nucleus, each provided with a centrosome, moving apart (Figs. 6 and 7). During this gradual movement, the nucleus assumes several shapes. The two centrosomes with their respective halves usually turn through 180°, resulting finally in a dumb-bell configuration. It appears that the angle of movement of the two separating halves may, however, vary—depending upon the relation between the plane of division and the position of the bud. Perfect dumb-bell configurations occur only when the angle is 180°, which happens in a majority of cases. The final separation of the daughter nuclei occurs when the nuclear membrane is stretched to the maximum. When this final separation occurs, one daughter nucleus is found in the bud and another in the mother cell (Figs. 8 and 9). If, however, the bud is far away from the plane of nuclear division or has not yet been formed, both the daughter nuclei may be found in the same mother cell. This scheme of nuclear division and separation is diagrammatically represented in Fig. 10, together with the schemes postulated by De Lamater[1], Lietz[2], and Lindegren *et al.*[4].

The method of nuclear fission and separation of daughter nuclei described above seems to be characteristic of *S. cerevisiae* in which there is apparently no synchronization in time between the appearance of the bud and any particular stage of mitosis. Neither is there any correlation between the point of origin of the bud and the plane of nuclear division. In *Schizosaccharomyces pombe*, cytokinesis is of the type seen in higher plants and the constriction in the nuclear membrane appears to start from both the ends, with the result that the different shapes of nucleus observed in *S. cerevisiae* during the separation phase are not seen. Mitosis is, however, intra-nuclear in all the yeasts studied by us.

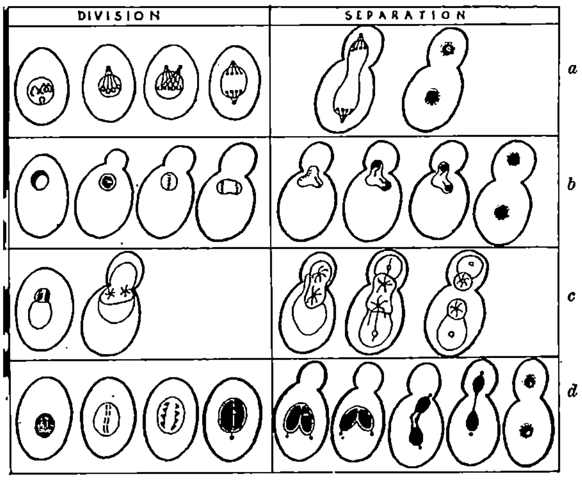


Fig. 10. Nuclear division and separation according to: *a*, De Lamater (ref. 1); *b*, Lietz (ref. 2); *c*, Lindegren *et al.* (ref. 4); *d*, the present authors.

De Lamater[1], Lietz[2], and Lindegren *et al.*[4] have used the terms 'anaphase' and 'telophase' to designate stages in the separation of the daughter nuclei, thus confusing the intra-nuclear separation of the divided chromosomes with the separation of the daughter nuclei by furrowing and subsequent movement. As a consequence, their schemes will demand both some form of synchronization between budding and anaphase of mitosis, and a localization of the point of origin of the bud with the plane of nuclear division. The doubling observed in many yeast nuclei at the end of mitosis but before separation of the daughter nuclei, as well as the lack of any relationship between budding and nuclear separation either in time or in plane of movement, supports our view that anaphase and telophase are actually completed within the nuclear membrane, thus effecting the regular distribution of the divided chromosomes prior to the initiation of a process analogous to cytokinesis in the nucleus.

We are indebted to Dr. B. P. Pal and Dr. S. M. Sikka for their interest in the study. Our thanks are also due to Prof. Ö. Winge and Dr. Catherine Roberts, of the Carlsberg Laboratory, Copenhagen, for critical advice on the manuscript.

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Heat as an Agent producing High Frequency of Mutations and Unstable Genes in *Escherichia coli*

MILD heating (up to 36° C.) is known to produce a small increase of the spontaneous mutation-rates in *Drosophila* and in bacteria. We have found that using special conditions it is possible to have mesophilic non-sporogenic bacteria (*Escherichia coli*) survive relatively high temperatures (60° C.) ; this sub-lethal treatment produces a high frequency of mutations and unstable genes.

Mutants of strain 15 (A.T.C.C. 9723) and of strain *W*6 ($F+$, mutant of $K12$)[1], yielding more survivors after heating (as below), have been isolated. 24- to 30-hr. old (37°) cultures in nutrient broth were heated by totally submerging stoppered tubes in a constant-temperature bath. In another procedure

Table 1. Stable and Unstable Mutants produced by Heat

Parent strain	Treatment	Survival (per cent)	I.C.*	Mutants			
				No. of different mutants	Description	Frequency	Stability
15 (heat resistant)	2 hr. 60° in sucrose	2×10^{-2}	+	2	Thiamine⁻	10^{-3}	Stable
	4 hr. 60° in sucrose	3×10^{-4}	+	3	'Pinpoint'	10^{-2}	Stable
	2–4 hr. 55°	2×10^{-2}–5×10^{-3}	−	4	Lactose⁻, maltose⁻	4×10^{-3}–5×10^{-2}	Stable†
	4 hr. 55°	5×10^{-3}	−	5	Partial lactose⁻	10^{-1}	Stable
	4 hr. 55°	10^{-3}	+	1	Glucose⁻, lactose⁻	2×10^{-2}	Unstable
	3–4 hr. 60° in sucrose	10^{-2}–3×10^{-4}	+	6	'Pinpoint'	10^{-2}–5×10^{-3}	Unstable
	4 hr. 55°	10^{-2}	+	4	'Pinpoint'	10^{-3}	Unstable
W6 (heat resistant)	½ hr. 60° in sucrose	6×10^{-5}	+	1	Purine⁻, thiamine⁻	10^{-3}	Stable
	2 hr. 60° dried	3×10^{-4}	+	2	'Pinpoint'	2×10^{-3}	Stable
	½ hr. 60° in sucrose	6×10^{-5}	+	2	'Pinpoint'	2×10^{-3}	Unstable

* Intermediate cultivation: None (−), or 18 hr., 37° in nutrient broth (+).

† Spontaneous 'back-mutation' (mutation-rate 3×10^{-11}) to lactose⁺, maltose⁻, to lactose⁺, maltose⁺; also directly to lactose⁺, maltose⁺

the cultures were suspended in 50 per cent sucrose, incubated for 2 hr. at 30° and then heated as above. In still another procedure the cultures were centrifuged, the pellet was dried in vacuum over phosphorus pentoxide for 2 hr. and then heated as above.

The survivors (Table 1) underwent phenotypic damage, which probably includes heat denaturation of synthesizing enzymes: after 3 hr. heating at 60° (strain 15 in sucrose), the survivors, which form colonies of various sizes on nutrient agar (non-hereditary changes), are unable to grow on minimal agar. This inability is also non-hereditary ('pseudo-auxotrophs').

The surviving populations in all heating experiments were searched for mutants by streaking on nutrient agar, Endo's agar, or minimal agar containing 0·05 per cent proteose peptone, either directly after heating or after intermediate cultivation in nutrient broth. The populations contained a very high proportion of mutants (Table 1). This high proportion already makes it unlikely that the mutants were present in the original populations and merely selected by heat treatment. However, to exclude further this possibility, several mutants were mixed with the original population and tested for survival in the same heating conditions. All these mutants were less resistant to heat than the original population, which indicates that the mutants were produced by heat and not selected by it. Similarly, the selection of mutants during the intermediate cultivation was excluded by the demonstration that the mutants grew more slowly in the nutrient broth than the original population. Thus, the actual mutation-rates may be higher than those which can be calculated from the mutant frequencies in Table 1.

The mutants isolated to date (Table 1) include those that occur spontaneously or can be readily induced by previously known agents as well as those rarely obtained by other means. Repeated incidence of thiamine⁻ mutants from different parent strains may also be unusual. Of particular interest are the unstable mutants, similar to the one which has occurred in unidentified circumstances[2] or to those which can be induced by 5-bromouracil in conditions of its incorporation into deoxyribonucleic acid of the cells[3]. The unstable mutants obtained by heating were isolated after intermediate cultivation as undersized colonies on nutrient agar; they mutated to 'pinpoint' colonies with high frequencies (of the order of 2×10^{-2}–10^{-1}); some of the 'pinpoints' were stable mutants whereas others mutated again to colonies of normal size (mutant frequencies 3×10^{-2} to 7×10^{-1}); some of the latter gave stable strains whereas others mutated again to 'pinpoint' colonies. At least four 'pinpoint' strains might be partially deficient nutritional mutants (full size colonies on richer N.I.H. agar ('Difco').

As mentioned before, some of the mutants induced by heat (non-fermenters, auxotrophs) are similar to known 'segregating' ('nuclear', 'chromosomal') mutants. This suggests that the heat-induced markers (mutants) are also 'segregating' rather than 'cytoplasmic'. However, more rigorous proof was desirable. To this end, a heat-induced purine⁻, thiamine⁻ mutant of strain *W6* was crossed with strain 1177 (*F*⁻, thiamine⁻)[1]. Out of 2,000 recombinants on minimal agar containing thiamine, 11 were isolated that were purine⁻; in addition, when a thiamine+ mutant of 1177 was used as *F*⁻, 1 per cent of recombinants was both adenine⁻, thiamine⁻; these results clearly indicate the 'segregational' nature of this heat-induced mutant. However, it is not unlikely that in addition to the segregating mutants studied here, heat treatment can also produce the non-reversible cytoplasmic mutants or some other unknown disturbances in the orderly process of heredity transmission.

From the foregoing, it is apparent that the mutagenic and unstabilizing effect of heat is of a different magnitude than that of other microbial mutagenic agents, with the exception of 5-bromouracil in the conditions of its incorporation into deoxyribonucleic acid[3]; as in the case of 5-bromouracil, heat as a mutagenic agent has the advantages that one can be sure that it reaches deoxyribonucleic acid and that the actual changes induced by it in this substance have been studied by physico-chemical methods. It has been suggested that the first action of the mutagenic agent is to bring the gene into an unstable state; if so, then the 'unstable mutants' are those which have not lost their instability after having mutated. If the role of cellular deoxyribonucleic acid is the determination of heredity, then its unstabilization is a likely cause of gene unstabilization. The unstabilization *in vitro* of deoxyribonucleic acid having transforming activity by heat has been demonstrated[4]; the conditions used were not much more drastic than those in the present work. Individual heredity determinants of the same cell have different stabilities towards heat[5]; it is not unlikely that some of them undergo unstabilization upon prolonged heating even at 55° or 60°. The demonstration that at least one heat-induced mutant is segregating ('chromosomal' mutation) also suggests that the damaged heredity determinant may be deoxyribonucleic acid.

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Desiccation of Eggs of the Crane Fly (*Tipula oleracea*, L.)

THE ease with which crane fly eggs lose water is of some ecological importance since the eggs are laid near the surface of the soil, among the bases of the grass stems. In this position they are likely to experience fairly wide fluctuations in humidity, at least during drought periods.

The egg is black, measures about 0·8 mm. by 0·3 mm. and has a long, thin filament attached to one end. The incubation period is six days at 21° C. The newlaid egg looks shrunken and wizened. After 5–10 min. it becomes slim and rounded. By the third day it has absorbed water and become considerably bigger.

Using the filament, eggs were suspended in dry air and observed. The first sign of collapse is a slight flattening of one side, closely followed by the appearance of a dimple. The time taken for the dimple to appear was recorded for eggs of different ages. This measurement could be important physiologically since the collapse of the shell might be expected to cause mechanical damage to the embryo.

Eggs up to 15 min. old dimple in 2–4 min. At 15 min. old the dimpling time increases sharply to between 10 and 25 min. It increases steadily thereafter and by the sixth day eggs take 1–1½ hr. to dimple.

Eggs of different ages (5 min., 1 hr., 1 day and 4 days) were then exposed to dry air for about three times the dimpling time at their respective ages. All survived. Another group of eggs, 1 hr. old, were exposed for 100 min. (five times the dimpling time) and only 35 per cent survived. Another experiment showed that eggs more than 1 day old can survive about 1 day at 75 per cent and 2–3 days at 90 per cent relative humidity.

Two interesting points emerge from these preliminary experiments. The egg can survive considerable mechanical deformation. After the first day eggs are able to stand quite severe conditions for at least 24 hr. (and humidities of less than 95 per cent, particularly in the grass mat, are likely to prevail for no longer than the daylight hours).

It seems likely, therefore, that in the field the egg runs little risk of death from desiccation except at the beginning of the embryonic period.

Full details of these and further experiments on the water relations of the crane fly egg will be published elsewhere.

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W. H. Perkin and the Young Chair of Technical Chemistry in the Royal College of Science and Technology, Glasgow

IN evidence on technical education given before the Select Committee on Estimates on June 19, 1953, and published in its twelfth report for the session 1952–53, Dr. (now Sir) D. S. Anderson, director of the Royal Technical College, Glasgow, mentioned that Prof. W. H. Perkin, of dye fame, had been a professor there. Afterwards, in an article on the Royal Technical College, Glasgow, in the *Journal of the Royal Institute of Chemistry* in 1954, Dr. J. A. Cranston, after stating that in 1870 James Young, who was at that time president of Anderson's University, founded the chair of technical chemistry which bears his name, giving 10,000 guineas to endow what was the first chair of applied chemistry in the United Kingdom and further sums of money to provide suitable buildings and fittings, added: "The first 'Young' Professor of Technical Chemistry, 1870–71, was William H. Perkin, discoverer of mauve dye and founder of the coal-tar colour industry".

This is not mentioned in any of the obituary notices of Perkin, and accordingly I made further inquiry of Sir David Anderson when preparing a paper on Perkin and the dyestuffs industry in Britain. In consequence, Sir David and the College librarian made further search into the matter. It appears that although the chair was offered to W. H. Perkin in September 1869, Prof. Penny, the then professor of chemistry, formally protested against the nomination and appointment of an additional professor of chemistry in, or in connexion with, Anderson's University, as adversely affecting his privileges and interests. As a result, Mr. Young withdrew the grant and asked the trustees to allow him to cancel the deed of foundation, and in July 1870 agreed to a modification of the trust deed to secure harmonious working with the existing chair of chemistry. The modified deed and the donation of £10,500 were accepted by the trustees of Anderson's University at a special meeting on July 12, 1870. Perkin's name is not mentioned in connexion with the new negotiations, so either the offer was not renewed or in the meantime he had definitely declined.

For reasons of space, no reference was made to this episode in my article in *Nature* of May 5, 1956, p. 815; but since in his recent history of the chemical industry, Haber (p. 75) writes, "James Young . . . endowed the Young Chair of technical chemistry at Anderson's University, of which he was one of the most distinguished graduates, in 1870. W. H. Perkin was the first professor, from 1870 to 1875, and was succeeded by E. J. Mills", it seems desirable to place the facts on record without further delay.

R. BRIGHTMAN

Red Lodge,
Cow Lane,
Norley, Cheshire.

FORTHCOMING EVENTS

Sunday, August 31—Wednesday, September 3

British Association for the Advancement of Science (at Glasgow).—Continuation of Annual Meeting.

Sunday, August 31

At 11 a.m.—(in Glasgow Cathedral)—Religious Service. Preacher: The Reverend Dr. Nevile Davidson, Minister of Glasgow.

Monday, September 1

At 10 a.m.—Dr. T. E. Allibone, F.R.S.: "Some Aspects of Thermonuclear Power" (Presidential Address, Section A).

At 10 a.m.—Prof. L. R. Wager, F.R.S.: "Beneath the Earth's Crust" (Presidential Address, Section C).

At 10 a.m.—Dr. Iorwerth C. Peate: "The Study of Folk Lore and Its Part in the Defence of Civilization" (Presidential Address, Section H).

At 10 a.m.—Dr. E. N. Willmer: "Some Aspects of Cellular Differentiation" (Presidential Address, Section I).

At 8 p.m.—Dr. C. F. A. Pantin, F.R.S.: "Living Machinery and the Electron Microscope" (Evening Discourse).

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Lecturers and Lecturers (with a degree or equivalent qualifications with suitable teaching and professional qualifications) in the Department of Mechanical Engineering, Kumasi College of Technology—Council for Overseas Colleges, 12 Lincoln's Inn Fields London, W.C.2 (September 5).

Assistant, Grade *B* (preferably with experience in industry, teaching and/or research) in General Chemistry—The Principal, Nottingham and District Technical College, Burton Street, Nottingham (September 6).

Research Assistant (with a good degree in chemistry or biochemistry, and preferably some research experience or qualification) in the Zoology Department, to investigate effects of chemical pollutants on marine organisms—The Secretary and Registrar, The University, Southampton (September 6).

Research Assistant (with a good honours degree, a knowledge of German and ability to draw maps) in the Department of Geography—The Registrar, The University, Leeds 2 (September 8).

Lecturer or Assistant Lecturer (preferably with some experience of X-ray crystallography) in Physics—The Registrar, The University, Sheffield (September 13).

Tutorial Research Student in Zoology—The Principal, Royal Holloway College (University of London), Englefield Green, Surrey (September 15).

Research Assistant (with a good honours degree in physics and some research experience) in the Department of Physics, to take part in research which is at present concerned with X-ray diffraction, physical optics, electronics and instrumentation—The Registrar, Manchester College of Science and Technology, Manchester 1 (September 20).

Keeper (with a good honours degree and preferably with the Diploma of the Museums Association) in the Department of Botany, Manchester Museum—The Registrar, The University, Manchester (September 30).

Lecturer (Grade I or II) (with interests in entomology or physiology) in Zoology at University College, Ibadan, Nigeria—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (September 30).

Senior Lecturer or Lecturer in Mathematics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

Soil Microbiologist (Mycologist) (with a good honours degree), for work on isolation and identification of possible vectors of soil-borne viruses; and an Entomologist/Virologist (with a good honours degree), for work on problems of virus transmission—The Secretary, Scottish Horticultural Research Institute, Mylnefield, Invergowrie, by Dundee (October 4).

Managing Director (with high level administrative experience together with a wide knowledge of the sciences and their industrial application, or proved ability to provide administrative leadership for a technological team) of the National Research Development Corporation—The Secretary, Board of Trade, Horse Guards Avenue, London, S.W.1, marking envelope "N.R.D.C. Application" (October 13).

Senior Lecturer in Mathematics at Victoria University of Wellington, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

Assistant Experimental Officer (with a suitable degree, G.C.E. with chemistry at advanced level, or equivalent qualifications) in the Chemistry Department, to help with research work on the composition of milk, milk products, feeding stuffs, etc.—The Secretary, National Institute for Research in Dairying, Shinfield, Reading, quoting Ref. 58/22.

Fisheries Officer (male, with a university degree in natural science (zoology) and preferably some experience of fishery administration) in Aden, to organize and develop the domestic fisheries of the Colony and Protectorate—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.65/2/01.

Lecturer in Mechanical Engineering, and a Lecturer in Mining Geology at the University of Rangoon, Burma—The Ministry of Labour and National Service (E.9), 26–28 King Street, London, S.W.1, quoting Ref. E.9/TCS/234-5-8/BUR.

Livestock Improvement Officer (with a university degre agriculture and considerable knowledge and experience of crop animal husbandry) in Gambia, to investigate fodder resources subsequently initiate a programme of work designed to establi mixed farming system of agriculture—The Director of Recruitn Colonial Office, London, S.W.1, quoting BCD.63/12/13.

Research Assistants in (*a*) Physics, and (*b*) Telecommun tions—The Clerk to the Governors, Woolwich Polytechnic, Lon S.E.18.

Research Officer (Biologist) (with a good honours degre zoology, a knowledge of marine biology, particularly fishes plankton, with preference and aptitude for work at sea) with East African Marine Fisheries Research Organization, Zan: —The Director of Recruitment, Colonial Office, London, S. quoting BCD.195/194/03.

Senior Experimental Officer (at least 35 years of age, wi pass degree, H.N.C., or equivalent qualification, and familiar high voltage laboratory techniques and pulse circuitry), to be sponsible for the construction of high energy condenser banks desi to produce very heavy current gas discharges—The Senior Rec ment Officer, Atomic Weapons Research Establishment, Alderma Berks, quoting Ref. 1963/2.

Senior Lecturer in Chemical Engineering, and a Se Lecturer in Metallurgy at the University of Rangoon, Burn The Ministry of Labour and National Service (E.9), 26–28 King St London, S.W.1, quoting Ref. E.9/TCS/236-7/BUR.

REPORTS and other PUBLICATIO

(*not included in the monthly Books Supplement*)

Great Britain and Ireland

The R.C.I. Standard, No. 1 (June, 1958). Pp. 16. (Lond Research and Control Instruments, Ltd., 1958.)

Sir John Cass College. Prospectus, Session 1958–59. Pp. (London: Sir John Cass College, 1958.)

Colonial Development and Welfare Acts. Return of Schemes m under the Colonial Development and Welfare Acts by the Secretar State for the Colonies, with the concurrence of the Treasury, in period from 1st April, 1957, to 31st March, 1958. Pp. 36. (Hous Commons Paper No. 223.) (London: H.M. Stationery Office, 19 2*s*. net.

Building Research Station Digest No. 111 (June, 1958): Corro of Non-ferrous Metals—2. Pp. 7. (London: H.M. Stationery Of 1958.) 3*d*. [

Ciba (A.R.L.), Limited. Technical Notes (July, 1958): "Aerod 185 at the Brussels Fair. Pp. 10. (Duxford: Ciba (A.R.L.), I 1958.) [

Medical Research Council. Technical Careers in the Medical search Council. Pp. 31. (London: Medical Research Cou 1958.) [

The National Institute of Agricultural Botany. Thirty-eig Report and Accounts, 1957. Pp. 56. (Cambridge: The Natio Institute of Agricultural Botany, 1958.) [

Other Countries

European Organization for Nuclear Research. Annual Rep 1957. Pp. 86 (25 plates). (Geneva: CERN, 1958.) [

Bulletin de la Société Préhistorique de l'Ariège. Tome XII: histoire Spéléologie Ariègeoises. Pp. 152+7 planches. (Tarascon-Ariège: M. Romain Robert, Place Jean-Jaurès, 1957.) [

Harvard University: Blue Hill Meteorological Observat Meteorological Radar Studies. No. 7: Particle Size Distributio Rain and Snow Inferred from Z–R Relations. By Raymond We Pp. i+8. No. 8: A System for Recording Eight Meteorolog Elements Simultaneously on Moving Film (Weatherlog). By G. Thompson. Pp. vii+60. No. 10: Vertical Structure of Continu Streamer-form Precipitation. By Raymond Wexler and David At Pp. vi+38. Final Report: Study of Synoptic-dynamic Influence the Nature of Cloud and Precipitation Echoes, October 1953–Febru 1958. Pp. ii+36. Meteorological Utilization of Images of the Ear Surface Transmitted from a Satellite Vehicle. By Arnold H. Gla Pp. x+145. (Milton, Mass.: Harvard University, Blue Hill Mete logical Observatory, 1957 and 1958.) [

The Carlsberg Foundation's Oceanographical Expedition Round World, 1928–30, and Previous "Dana" Expeditions. "Dana" Rep No. 44: The Marine Water-Striders of the "Dana" Expediti (Insecta: Hemiptera). By Jon L. Herring. Pp. 14. 2 D. Kr. "Da Report No. 45: The Argentinoid Fish *Xenophtalmichthys da* By E. Bertelsen. Notes of Miripinnati (An addendum to "Da Report No. 42). By E. Bertelsen and N. B. Marshall. Pp. 10 plate. 2 D. Kr. (Copenhagen: Andr. Fred Høst & Søn, 1958.) [

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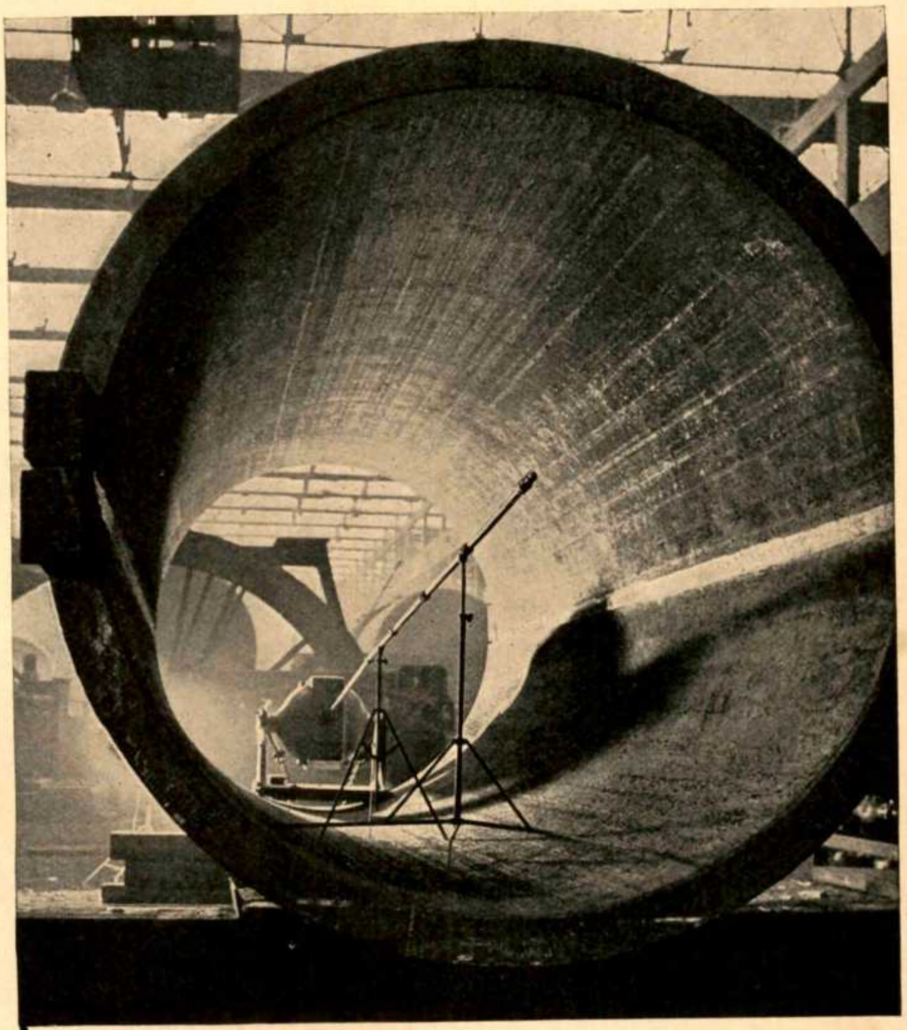

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More power for industry means increased prosperity for the nation. And so it is, as the programme for building nuclear generating stations goes ahead, that photography, with its partner, radiography, has a stake in Britain's future. For here is a vast co-operative effort in which many of the problems of research, design and construction depend for a solution on photographic methods.

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LECTURES AND COURSES

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3
DEPARTMENT OF CHEMISTRY
SESSION 1958-59

A course of 20 postgraduate lectures on "Biochemistry" (to be arranged in four groups) will be given by Dr. E. M. Crook, M.Sc., and Professor F. L. Warren, M.A., D.Sc., on Mondays, 7.15 to 8.30 p.m., during the period October 6, 1958, to March 16, 1959. The course is designed for students who possess a knowledge of chemistry to degree standard. Fee: £2 for whole course or 10s. for each group.

A leaflet giving details is obtainable from the Secretary.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3
DEPARTMENT OF GEOLOGY
Head of Department: W. E. Smith, M.Sc., F.G.S.
ORE-DRESSING

A course of ten lectures on the mineralogical aspects of ore-dressing will be given by Dr. E. Cohen on Wednesday evenings during the Autumn Term. 1958. The course is intended for graduates in Geology and metallurgists with a basic knowledge of mineralogy.

Further information may be obtained from the Head of the Department.

THE POLYTECHNIC

309 REGENT STREET, W.1
DEPARTMENT OF MATHEMATICS AND PHYSICS

The following courses of lectures have been arranged, starting in September, 1958:

1. MATHEMATICAL STATISTICS
   on Tuesday, Thursday and Friday evenings.
2. ADVANCED MATHEMATICS FOR SCIENTISTS AND ENGINEERS
   on Wednesday evenings.
3. MODERN ELECTRIC NETWORK THEORY
   on Friday evenings.
4. FINITE DIFFERENCE EQUATIONS AND DIFFERENCE-DIFFERENTIAL EQUATIONS
   on Monday evenings.
5. INTEGRAL EQUATIONS AND GREEN'S FUNCTIONS
   on Wednesday evenings.
6. AUTOMATIC DIGITAL COMPUTERS
   on Tuesday evenings.
7. ELECTRONICS
   on Monday, Wednesday and Thursday evenings.

Full particulars may be obtained on application to the Director of Education.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

LONDON, S.W.7
CHEMICAL ENGINEERING DEPARTMENT
POSTGRADUATE COURSES IN INDUSTRIAL SAFETY

Full- and part-time courses in Industrial Safety (with particular reference to the Chemical Industry) arranged under the direction of Dr. J. H. Burgoyne, will be available for graduates in Chemistry, Chemical Engineering and related subjects during the session commencing October 1, 1958.

Further particulars from the Registrar, Imperial College, London, S.W.7.

SHORT POSTGRADUATE COURSES IN Chemical Physics, suitable for graduate students or for research workers in related fields, will be held during the 1958-1959 Session. The Courses are of 5 to 12 lectures' duration and deal with the following topics: rate processes in solids, electronic properties of solids, crystal growth, rate processes in liquids, and the thermodynamics of liquids, gases and solutions.—Further information from the Registrar, Imperial College, London, S.W.7.

OFFICIAL APPOINTMENTS

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Research Assistant to the Professor of Mining, to begin duties as soon as possible. Salary up to £800 with F.S.S.U. provision and family allowance. Applicants should have a good degree in mining, engineering or pure science.

Further particulars should be obtained from the Registrar, to whom applications (four copies) should be sent by September 20, 1958.

UNIVERSITY OF LEEDS

UNITED LEEDS HOSPITALS
DEPARTMENT OF MEDICAL PHYSICS

Applications are invited for the post of Physicist at a salary on the scale £625 by £25 to £700 a year, according to qualifications and experience. Candidates should have an honours degree in physics, but experience in radiation work is not essential. Duties will be concerned with problems of radiation protection and research in related fields. Facilities are available in the department for acquiring experience in the applications of physics to medicine and for preparing for a higher degree.

Applications (three copies), stating date of birth, qualifications and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than September 1, 1958.

SENIOR SCIENTIFIC OFFICERS

required by

THE ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKSHIRE

for duty at Orfordness, Suffolk

Post 1. To be directly responsible to the Officer-in-Charge for the general direction and management of a team engaged on a programme of advanced development and complex field trials. Good organizing ability and interest in technical management are essential for this post.

The team is responsible for the design of airborne telemetry equipment and associated ground stations, the organizing and carrying out of complex field and flight trials and the evaluation of the results. There is ample scope for original design.

Post 2. To take charge of a section of the above team engaged in advanced electronic instrumentation development and to be responsible for the detailed technical direction of this work.

For both posts a first- or second-class honours degree or equivalent is required and several years' experience in electronics or communication equipment development including pulse and U.H.F. techniques. Experience in air borne radar and G.W. equipment development will be considered a distinct advantage.

Salary: £1,215 to £1,425 per annum.

Contributory Superannuation Scheme. A house, or assistance towards legal expenses on house purchase, will be available for married officers living beyond daily travelling distance.

Postcards for application forms to the Senior Recruitment Officer at A.W.R.E., Aldermaston, Berks. Please quote ref. 1969/34.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Senior Lecturer or Lecturer in Botany. Salary scales per annum: Senior Lecturer, £1,700 to £2,050; Lecturer, £900 to £1,650; initial salary and status according to qualifications and experience. Membership of F.S.S.U. and Children's allowance scheme. Candidates should have special qualifications in plant physiology, and preference will be given to persons with interests and research experience in biochemistry.

Applications should be sent not later than September 30, 1958, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

DIRECTOR

CAWTHRON INSTITUTE, NELSON, N.Z.

Applications for the above position are invited from those who are academically well qualified, of proven scientific leadership and administrative ability, to develop researches primarily into plant nutrition problems of horticulture and agriculture. Salary scale £2,000 to £2,250.

Details are obtainable from the Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, N.Z., or the N.Z. High Commissioner, 415 Strand, London, with either of whom applications close on September 30, 1958.

COMMONWEALTH of AUSTRAL

AUSTRALIAN ATOMIC ENERGY
COMMISSION
CHEMISTRY SECTION. APPOINTMENT
SENIOR RESEARCH OFFICER OR
PRINCIPAL RESEARCH OFFICER (£A.2,06
£A.2,336 or ; £A.2,556/£A.2,996)

A vacancy exists for an experienced resea
chemist to take charge of a group within
Chemistry Section of the Commission's Resea
Establishment at Lucas Heights, Sydney.
position holds good prospects of promotion a
further responsibility. The Commission's resea
programme includes the study of two high te
perature reactor systems and of the reprocessi
of a range of nuclear fuels. A feature of the
search programme is the interest in berylliu
both as a moderator and fuel diluent. The n
chemical laboratories at Lucas Heights are of
very high standard of construction and are
cellently equipped for radiochemical work as w
as for more conventional instrumental and
organic studies. Irradiation facilities will
available in the Commission's recently comple
high-flux research reactor (H.I.F.A.R.). Qual
cations. Applicants should possess at least a fir
or second-class honours degree, and have had su
stantial research experience, preferably in the fie
of inorganic or physical chemistry. Radiochemi
experience would be an advantage. The salary
appointment will be dependent upon qualificatio
and experience. Conditions. Confirmation of
pointment carries with it Commonwealth Supera
nuation Fund or Commonwealth Provid
Account privileges. In the case of applicants fr
overseas, consideration will be given to a thr
year appointment. First-class fares and settling
allowances will be paid by the Commission.

Further information concerning the Commiss
may be obtained from the Commission's Liais
Officer in Australia House. Applications, givi
full name, date and place of birth, nationali
marital status, present position and salary, qua
fications, experience, particulars of any public
tions, the names and addresses of at least tw
referees, who may be contacted re technical
perience, and when available for duty, should
forwarded to the A.A.E.C. Liaison Offic
Australia House, Strand, London, W.C.2, n
later than Friday, September 19, 1958.

SIERRA LEONE

SYSTEMATIC BOTANIST/ECOLOGIST

To study grass weed problems of the inla
rice bolis and to advise on control measures;
study problems of low fertility and yields in are
being developed for mechanical rice cultivatio
Candidates must have an honours degree in bota
and at least two years' research experience pref
ably in ecology; or an honours degree or equiv
lent in agricultural science plus two years co
pleted postgraduate training in botany, preferab
with an ecological bias. Agricultural and tropic
experience would be an advantage. Age: N
over 35. Appointment is on (i) permanent a
pensionable terms with pensionable emolumen
in range £966 to £1,776 per annum (ii) perma
ent Research Branch terms, or (iii) on contrac
gratuity terms with emoluments in scale £1,039
£1,924 with a gratuity of £37 10s. for each co
pleted period of three months' satisfactory servi
payable on completion of engagement. Free pa
sages for officer, wife and up to two depende
children under nineteen years of age. Furnish
quarters, when available, at moderate rental. O
fit allowance £60 on first appointment. Taxati
at local rates.

Apply, giving brief particulars, to Director
Recruitment, Colonial Office, London, S.W.
quoting BCD.63/15/012.

NORTH OF SCOTLAND COLLEG OF AGRICULTURE

Applications are invited for the following sta
vacancy: Assistant Advisory Officer in Grasslar
Husbandry. Candidates should possess an honou
degree in agricultural botany or a B.Sc. pass d
gree in agriculture. Specialized postgraduate e
perience in Grassland Husbandry is desirable b
not essential. The duties will include investig
tional work. Salary scale, National (men), Gra
III, £835 to £1,320 per annum; Grade IVa, £6
to £825 per annum; Grade IVb, £595 to £825 p
annum. Entry to one of the above scales will
according to age, qualifications and experience a
the successful candidate must be prepared to ser
in any part of the College area. Superannuati
scheme.

Forms of application, which may be obtain
from the Secretary of the College, must be lodg
not later than September 20, 1958.

41½ Union Street,
Aberdeen.

RTH OF SCOTLAND COLLEGE OF AGRICULTURE

pplications are invited for the post of Assist- Lecturer in Bacteriology. Candidates must be luates and for a Grade III appointment should e had suitable postgraduate experience. The essful candidate will be required to take part he lecturing and advisory investigational work he Department. The appointment will be on of the following salary scales with entry rding to qualifications and experience: Grade (men), £835 to £1,320; (women), £788 to 51. Grade IVa (men), £615 to £825; men), £615 to £787. Grade IVb (men), £595 825; (women), £595 to £787. Superannuation me.

urther details and application forms may be ained from the undersigned, with whom appli- ons must be lodged not later than September 1958.

HUGH MUNRO,
Secretary.

1½ Union Street,
Aberdeen.

QUEEN MARY COLLEGE

(UNIVERSITY OF LONDON)

MILE END ROAD, E.1

NUCLEAR ENGINEERING LABORATORY

RESEARCH ASSISTANT

To help in developing equipment and to supervise the laboratories. Experience in a laboratory, adaptability and enthusiasm are more important than paper qualifications. Electronic and nucleonic experience desirable, but training in nucleonics will be given where necessary. Appointment according to ability, etc., on scale £800 by £35 to £1,000 per annum. Pension scheme. Five-day week. Four weeks annual leave.

Letters only to Professor Murgatroyd, stating age, details of experience and present work.

FEDERATION OF NIGERIA

NCIPAL FISHERIES RESEARCH OFFICER

o lead a small group of scientists and techni- ıs in either Sea Fisheries Research or Inland heries and Fish Culture Research. Candidates st have a good honours degree in zoology and siderable postgraduate experience in fisheries earch. Appointment on contract gratuity terms a salary of £2,082 per annum. Gratuity of 10s. for each completed period of three nths' service (including leave). Free passages on ointment and leave for officer, wife and chil- n up to the equivalent of four adult passages ll. Furnished quarters if available at moderate tal. Generous leave.

pply, giving brief particulars, to Director of ruitment, Colonial Office, London, S.W.1, ting BCD.65/14/03.

ITY OF LEICESTER MUSEUMS AND ART GALLERY

PPOINTMENT OF KEEPER OF BIOLOGY

pplications are invited for appointment to the t of Keeper of the Department of Biology in Leicester Museums. Candidates should norm- hold a degree in botany or zoology, or the ploma of the Museums' Association and should e considerable museum experience. The salary be within APT Grade III (£845 to £1,025 per ıum), and the successful candidate will be re- red to pass a medical examination.

pplications, giving full details of qualifications l experience, should reach the undersigned by tember 30, next, and further particulars are ilable on request. There is no entry form.

T. A. WALDEN,
Director.

Museum and Art Gallery,
New Walk, Leicester.

NIVERSITY OF MANCHESTER

pplications are invited from graduates in chem- y or biochemistry for the post of Research sistant in Chemistry in connection with a grant m the British Empire Cancer Campaign Com- tee for work on the chemistry of nucleotides. lary would be £350 per annum. The person pointed would be required to take up duties on tober 1, 1958.

pplications should be sent not later than Sep- ıber 13, 1958, to the Registrar, the University, nchester 13, from whom further particulars and ms of application may be obtained.

CENTRAL ELECTRICITY GENERATING BOARD

RESEARCH AND DEVELOPMENT DEPARTMENT

Applications are invited for the post of DIRECTOR OF DEVELOPMENT PROJECTS (ELECTRICAL) in the Research and Development Department of the Central Electricity Generating Board at Headquarters, London, S.E.1. The successful candidate will be responsible to the Chief Research and Development Officer for the economic assessment, initiation and headquarters supervision of development projects in the fields of electrical equipment, transmission and system control undertaken both at out-stations and at the Board's Laboratories.

This is a senior appointment requiring wide experience of research or project direction in the fields of physics or electrical engineering. Previous experience in the heavy electrical supply or manufacturing industries would be an advantage but is not essential.

Candidates should have a good honours degree in science or engineering, or equivalent qualification.

Salary will be on a scale within the range of £2,960 to £3,860 per annum according to the agreed duties and responsibilities of the post.

Letters of application, stating age, qualifications and experience, present position and salary, should be forwarded to S. S. Scott, Chief Personnel Officer, Buchanan House, 24-30 Holborn, London, E.C.1, by September 8. Please mark envelopes "Confidential"—Ref. N./225.

UNIVERSITY OF ABERDEEN and ROBERT GORDON'S COLLEGES

Applications are invited for the post of University Lecturer in Mechanical Engineering. Candidates should preferably have qualifications in applied thermodynamics. An interest in heat transfer apparatus, or in the special problems associated with the generation of heat and power from nuclear reactors, and some industrial or research experience would be an advantage. There are excellent facilities for research or advanced studies requiring appreciable quantities of steam or compressed air. The University Regulations permit members of the teaching staff to read for the degree of Ph.D. by research. Salary in range rising to £1,650, with membership of the F.S.S.U. and children's allowances. Initial salary according to qualifications and experience. University owned accommodation becomes available from time to time.

Further information may be obtained from the Secretary, the University, Aberdeen, with whom applications (20 copies), giving names of three referees, should be lodged not later than October 1, 1958. An applicant outside the British Isles may submit one copy of application.

COMMONWEALTH BUREAU OF HELMINTHOLOGY

THE WHITE HOUSE, 103 ST. PETER'S STREET, ST. ALBANS, HERTS

Scientific Assistant required for work in scientific information service involving abstracting and indexing. Good science degree, reading knowledge of two European languages (preferably other than French or German) and ability to write good English essential. Knowledge of helminthology an advantage. Salary scale £595 to £970 (bar) to £1,330 (bar) to £1,460. Age, qualifications and experience considered when fixing starting salary. Up to two increments for compulsory National Service and two extra increments on completing two years' satisfactory service if aged 32 and under. Superannuation according to F.S.S.U.

Applications, stating age, qualifications and experience, together with names of three referees, should be sent to the Director before September 30, 1958.

UNIVERSITY OF CAMBRIDGE

Applications are invited for an Assistant Director of Research in general surface chemistry and colloid science. Applications will close on October 10, 1958.

Details of duties, salary, etc., may be obtained from Dr. F. B. Kipping, University Chemical Laboratory, Lensfield Road, Cambridge.

LABORATORY TECHNICIAN AND Student Technician required to assist in the general work of the Physics Department. Salary, Technician £535 to £660, Student Technician up to £456, according to age, training and experience.—Apply, Secretary, St. Mary's Hospital Medical School, Paddington, W.2.

DEPARTMENT OF AGRICULTURE

TANGANYIKA

PLANT PATHOLOGIST

Required for field and laboratory work in the diagnosis and investigation of fungal and bacterial diseases of crop plants and the testing of control measures. Candidates, male, must have a good honours degree in agriculture or natural science with at least one year's postgraduate training in mycology and plant pathology. A knowledge of virus diseases is desirable. Appointment on contract/gratuity terms with emoluments in range £981 to £1,863 per annum. Gratuity of 13½ per cent of total substantive emoluments at satisfactory conclusion of service. Outfit allowance £45 if emoluments do not exceed £1,284 per annum on first appointment. Furnished quarters, when available, at moderate rental. Free passages on appointment and leave for officer, wife and dependent children under 18 years of age up to a maximum equivalent to three adult passages in all. Taxation at local rates.

Apply, giving brief particulars, to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/8/08.

RADIO-ISOTOPES IN INDUSTRY AND RESEARCH

An Experimental Organic Chemist is required, initially at Harwell and later at the nearby Wantage Radiation Laboratories, for work on organic and physical-organic chemical problems in the application of radioisotopes in industry and research.

Appropriate H.N.C. "A" level G.C.E. subjects, or equivalent qualifications required. Experience of chromatography and methods used in determination of carbon 14 and/or tritium in organic materials desirable.

Salary: £420 to £855 or £990 to £1,215 according to age and experience.

Send postcard to the Group Recruitment Officer (1183/37), U.K.A.E.A., Atomic Energy Research Establishment, Didcot, Berks, for application form and details.

SOMERSET RIVER BOARD

ASSISTANT IN THE FISHERIES AND POLLUTION DEPARTMENT

Applications are invited for the above appointment on Salary Grade A.P.T. II (£725 to £845). Applicants should have some knowledge of fresh water biology and chemistry. Duties will include inspection of sewage works and trade waste treatment plants, river surveys and the examination of samples. It will be an advantage if the person appointed is able to drive a car, for which an allowance will be paid. The post is superannuated and subject to N.J.C. conditions.

Applications, stating age, qualifications and previous experience, must reach the undersigned by September 15, 1958.

E. L. KELTING, O.B.E., J.P., M.I.C.E.,
Chief Engineer.

The Watergate, West Quay.
Bridgwater, Somerset.

NEW SOUTH WALES DEPARTMENT OF PUBLIC HEALTH

SYDNEY, AUSTRALIA

Applications are invited for appointment to the position of Officer-in-Charge, Radiation Branch, Division of Industrial Hygiene. Salary £A.2,000 to £A.3,000 per annum. Commencing rate according to qualifications and experience. Applicants must possess a university degree in science or engineering, with majors in physics and/or mathematics, or other equivalent qualifications. Special experience in radiational work is essential. The successful applicant will be mainly concerned in the administration of the Radioactive Substances Act and Regulations thereunder and will be required to organize and administer a new Branch of the Department. He will be required to advise the Department in all matters pertaining to radioactive isotopes and irradiating apparatus in regard to which he must have thorough experience. Administrative experience is also desirable. First-class ship fares to Sydney of appointee and family will be paid. Successful applicant will be eligible, subject to passing a medical examination, to contribute to the State Superannuation Fund.

Four copies of applications (including the names of two referees) should be lodged with the Agent-General for New South Wales, 56 Strand, London, W.C.2, by October 7, 1958.

GOVERNMENT OF HONG KONG

Physicist required for Radiological Department to collaborate with Radiologists on treatment techniques, supervise radiological workshop, assist in maintenance and development of equipment, maintain radiation protection services and instruct students. Appointment on contract for three years but shorter period could be arranged if necessary. Emoluments include basic salary on scale from £1,035 to £1,897 10s. a year; expatriation pay from £210 to £281 10s. a year; and variable cost of living allowance, which on minimum of salary scale is £41 a year for single man; £175 a year for married man with no children; and £310 a year for married man with dependent children, boys under 18 and girls under 21 years. Commencing salary depends on experience. On satisfactory completion of service a gratuity is payable from £37 10s. to £62 10s. for each completed period of three months' service. Arrangements could be made for preservation of superannuation rights of candidate from National Health Service. Free passages for officer, wife and up to three children under 18. Pending quarters becoming available, hotel or hostel accommodation provided. Maximum charge for quarters, hotel or hostel accommodation one-seventh of basic salary. Income tax at local rates. Climate favourable. Educational facilities available. Candidates must possess honours B.Sc. degree in physics and have had at lease five years' post-qualification experience as hospital Physicist.

Application forms from Director of Recruitment, Colonial Office, London, S.W.1 (quoting BCD. 117/51/013).

UNIVERSITY COLLEGE OF RHODESIA AND NYASALAND

Applications are invited for Lectureship in Chemistry from candidates with interests in Physical and/or Inorganic Chemistry. Salary scales: Assistant Lecturer, £1,050 by £50 to £1,200 per annum, Lecturer (Grade II), £1,200 by £50 to £1,450 per annum (Grade I) £1,450 by £50 to £1,750 per annum, entry point determined by qualifications and experience. Superannuation scheme. Passages to Salisbury for appointee, wife and dependent children on appointment with allowance for transport of effects. Unfurnished accommodation at rent of up to 15 per cent of salary. Assistance given for triennial leave overseas.

Detailed applications (six copies), naming three referees, by October 10, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

GUIDED WEAPONS. PHYSICISTS AND ENgineers required by Ministry of Supply at Royal Aircraft Establishment, Armament Research and Development Establishment and Royal Radar Establishment, for research on guided weapons (including ballistic missile) and supervision of development in industry. First- or second-class honours degree or equivalent required for Scientific Officer (£595 to £1,050) and three years' postgraduate experience in addition for Senior Scientific Officer (£1,130 to £1,330). Women's rates the same by 1961. Superannuation under F.S.S.U. Opportunity for those under 32 to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1 (quote A.291/8A).

ROYAL NAVAL SCIENTIFIC SERVICE REquires Senior Scientific Officers and Scientific Officers for Establishments in London area, Baldock, Portsmouth, Portland, Poole, Greenock and Rosyth. Main requirements are about 25 vacancies for Physicists, Electronic Engineers and Mathematicians in areas specified. The following particular vacancies also exist: Mechanical Engineer for work on gas turbine problems in the London area. Mechanical Engineers for work on design and development of U/W devices in Portland area. Metallurgists for Rosyth and Poole. Chemists (Physical and Inorganic) for Poole area, Baldock and London. Candidates must normally be natural born British subjects of natural born British parents, with at least first- or second-class honours degrees or equivalent high professional attainments. Senior Scientific Officers must have had at least three years' postgraduate experience and be not less than 26 years of age. Salaries (men): Senior Scientific Officer, £1,190 to £1,410; Scientific Officer, £635 to £1,110 (London)—somewhat lower in provinces. Appointments unestablished (with F.S.S.U. benefits), but opportunities may occur for those between the ages of 21 and 32 to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A98/8A.

ROYAL PERTH HOSPITAL
WESTERN AUSTRALIA

require a

SENIOR TECHNICIAN (CHEMIST)

for routine chemical pathology, special investigations and research, in the Biochemistry Department at this hospital. Qualifications: Degree or equivalent in chemistry or biochemistry, with experience in clinical or research biochemistry. Salary: According to qualifications and experience, but in the range of: males, £A.1,420 to £A.1,465 to £A.1,510 to £A.1,555 to £A.1,600 per annum; females, £A.1,075 to £A.1,115 to £A.1,155 to £A.1,195 to £A.1,235 per annum.

In addition to all relevant personal details, applications must include particulars of experience and qualifications, the names of two referees, and should be addressed to the undersigned, not later than September 30, 1958.

JOSEPH GRIFFITH,
Administrator.

UNIVERSITY OF LEEDS
DEPARTMENT OF MECHANICAL ENGINEERING

Applications are invited for appointment to the post of Assistant Lecturer or Lecturer in the Department of Mechanical Engineering at a salary within the range £700 to £850 a year for an Assistant Lecturer or on the scale £900 by £50 to £1,350 (efficiency bar) by £75 to £1,650, according to age, qualifications and experience. The person appointed would be expected to work in the general field of mechanical engineering but to take particular interest in control engineering. Knowledge of the aspects of control engineering which are related to production engineering would be useful. Previous teaching experience is not necessary but industrial experience is essential.

Applications (three copies), stating date of birth, qualifications, and experience, together with the names of three referees, should reach the Registrar, the University, Leeds, 2 (from whom further particulars may be obtained), not later than September 30, 1958.

CENTRAL ELECTRICITY GENERATING BOARD
METALLURGIST—RESEARCH LABORATORIES

METALLURGIST required at RESEARCH LABORATORIES, Leatherhead, Surrey, to assist in investigating unusual problems in the creep of metals used in nuclear power generation. Candidates should be L.I.M. or hold the H.N.C. in metallurgy or physics. Experience in conventional creep testing will be a recommendation, but applicants without experience in this field will be considered. Salary will be within scales £820 to £995 per annum or £550 to £725 per annum, according to qualifications and experience.

Applications, stating age, qualifications, experience and present position and salary, should be forwarded to I. G. Ellis, Personnel Officer, 24-30 Holborn, London, E.C.1, by September 12. Please mark envelopes "Confidential." Ref. N./244.

SENIOR SCIENTIFIC AND SCIENTIFIC Officers, required at Government Communications Headquarters, Cheltenham, for telecommunications and electronic research in following fields: V.H.F. receiver design and microwave techniques; propagation trials; applications of semi-conducting devices; high speed electronic switching; data storage and handling; computer programming, and operational research. Candidates must normally be natural born British subjects of natural born British parents. First- or second-class honours degree in physics, mathematics or engineering or equivalent, at least three years' postgraduate experience for Senior Scientific Officer. Salaries for men (provincial rates) Senior Scientific Officer, £1,130 to £1,330; Scientific Officer, £595 to £1,050 (according to age and qualifications). Appointments unestablished but opportunities to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A147/8A.

AGRICULTURAL RESEARCH COUNCIL invite applications from persons qualified either in plant physiology or plant biochemistry to work on plant growth substances in their plant growth substance and systemic fungicide Unit at Wye College, near Ashford, Kent, under the direction of Professor R. L. Wain. Appointment in Scientific Officer (£595 to £1,080) or Senior Scientific Officer (£1,130 to £1,370) grade according to age and experience. Superannuation under F.S.S.U.—Applications, with copies of two recent testimonials, and names of three referees, to the Director of the Unit not later than September 30, 1958.

NEW SOUTH WALES UNIVERSI OF TECHNOLOGY
SYDNEY, AUSTRALIA
VACANCIES FOR SENIOR LECTURERS LECTURERS IN THE SCHOOL OF HUMANITIES AND SOCIAL SCIENCES

The University invites applications for appo ment to academic vacancies in the School Humanities and Social Sciences. Salary, Ser Lecturers: £A.2,211 range £A.2,561 per ann Lecturers: £A.1,511 range £A.2,111 per ann Commencing salary according to qualifications experience. Applicants for Lectureship m possess a degree preferably with honours, equivalent qualifications. For appointment Senior Lecturer an honours degree is essential.

Senior Lecturer/Lecturer in Sociology: Ap cants to be qualified in Sociology or So Anthropology, or in some related field that cludes substantial work in sociological theory method.

Lecturer in Philosophy: Applicants to be qu fied in Philosophy and qualifications in one more of the sciences and ability to lecture History and Philosophy of Science will be advantage.

Lecturer in Government: Applicants to be qu fied in political science or some allied study.

Appointees will be eligible, subject to passin medical examination, to contribute to the St Superannuation Fund. First-class ship fares Sydney of successful applicants and their fami will be paid.

Applications (including the names of t referees) should be lodged with the Agent-Gene for New South Wales, 56 Strand, London, W.C and a copy forwarded by airmail to the Burs New South Wales University of Technology, I 1, Post Office, Kensington, New South Wa Australia, before September 20, 1958.

UNIVERSITY OF SHEFFIELD

Applications are invited for a post of Jun Research Fellow in Geography to begin duties October 1, 1958. Salary £550 per annum. T appointment will be for one year in the first stance, but will be renewable.

Applications (three copies), with the names a addresses of two referees, should reach the Re trar, from whom further particulars may be tained, by September 13, 1958.

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HOLLOWAY, LONDON, N.7

Applications are invited from Honours Gra ates in Physics for appointment as RESEAR ASSISTANTS for problems concerned with f particle techniques, gas discharges, spectrosc and electronics. Candidates appointed can qua by research for the Ph.D. degree. Rate of pay approximately £480 per annum.

Further particulars and form of application tainable from the Clerk to the Governors.

BRITISH GUIANA
AGRICULTURAL SUPERINTENDENTS

Duties mainly concerned with agricultural tension work and management of demonstrat farms and stations. Candidates must have a u versity degree in agriculture or horticulture and least two years' suitable postgraduate training experience. Appointment on probation to permanent and pensionable establishment w salary in scale £770 to £1,400 per annum or contract/gratuity terms if preferred. Gratuity the rate of 22¼ per cent of salary. Free passa on appointment for officer, wife and children exceeding five persons in all. Assisted leave p sages. Unfurnished quarters at moderate rental

Apply, giving brief particulars, to Director Recruitment, Colonial Office, London, S.W quoting BCD.63/30/011.

SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

Applications are invited for two posts as Sci tific Officer: (1) Soil Microbiologist (Mycologi for work on isolation and identification of possi vectors of soil-borne viruses. (2) Entomologi Virologist for work on problems of virus transm sion. Salary scale £595 to £1,050. Placi F.S.S.U. Candidates should have a good hono degree in appropriate subjects.

Applications, giving age, full details of edu tion, qualifications, experience and naming th referees, will be considered from home candida and overseas candidates due to return to t country in the reasonably near future, and sho reach the Secretary, Mylnefield, Invergowrie, Dundee, not later than October 4. There are application forms.

NATURE

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SCIENTIFIC RESOURCES AND ATOMIC ENERGY

THE fourth annual report of the United Kingdom Atomic Energy Authority*, covering the year ended March 31, 1958, records substantial progress in the Authority's commitments in regard to defence, research and development on the civil applications of nuclear energy, consultancy service to the electricity authorities and collaboration with industry in the nuclear power programme. As was the case with previous reports, it is still impossible to assess the magnitude of the Authority's demand upon the resources of Great Britain in either man-power or materials. The operating account continues to be withheld from publication in the interest of national security, and the balance sheet merely records an item of £2,398,971 for research and development expenditure in aid of design (as against £2,691,341 the previous year). However reasonable that particular course may be, an assessment of the nation's research and development effort as a whole is becoming increasingly necessary, and it would seem from the report that defence considerations are a serious obstacle.

Nevertheless, the report provides a convenient and authoritative review of the Authority's many-sided contribution to Britain's economic development, the value of which is not seriously diminished by the fact that security considerations have been allowed to impose secrecy a little beyond what was essential and thereby hindered discussion of those features of the year's work which have excited most interest and aroused most concern. The time factor may account for the absence of the information which would enable some judgment to be made as to how far the Authority has been able to implement the recommendations of the Fleck reports and eliminate the fundamental weakness which the Windscale accident laid bare, namely, the spreading of the strictly limited amount of skilled staff ever more thinly over a rapidly expanding organization. As regards the future, industrial application of nuclear energy secrecy has not prevented the publication of an outline of the position. Nevertheless, it is important not merely that secrecy should be kept to the minimum but also that there should be general confidence that this is being done.

On this last point the present report adds nothing to the statement of policy given in the previous annual report, and it should be obvious that in the aggregate the functions which the Authority has assumed in regard to education and in its relations with industry must have a considerable effect in disseminating information about nuclear energy, quite apart from publication policy proper and the considerable programme of exhibitions described in this report. The publication policy, including the numerous papers and addresses contributed by the Authority's members and officers, which numbered more than 1,400 during the year, has made much of the information on research and development described in this report familiar to readers of *Nature*, so that recapitulation is unnecessary. It may suffice to note that the uranium situation has eased and that the Authority's interest in helium as a heat-transfer medium has led to drilling at a site in Tanganyika where unusually high concentrations have been reported. The Windscale accident, however, has demonstrated convincingly the value and importance of effective public relations. Indeed, it is perhaps only with that as background that the fullest benefits to all concerned arise from the contacts with industry described in the report under "Relations with Industry".

The Authority can only accommodate a limited number of attached staff, but the hundred or so scientists and engineers from British industry attached to the Authority's establishments at the end of the year are promoting a valuable interchange of ideas between the Authority and industry, acquiring experience for themselves which is not obtainable elsewhere and reinforcing the Authority's own technical resources ; no less important, they supplement the contribution to technological education which is made by the Harwell Reactor School and the Calder Operations School, and the five conferences held at Harwell during the year. The Reactor School extended its scope considerably, and the first six weeks of the standard course, which has been increased from fourteen to sixteen weeks, are now held at the Birmingham College of Technology, Bradford Institute of Technology, or Salford Royal Technical College. These courses and the Senior Technical Executive Courses and other courses during the year were attended by 378 British and 120 overseas students, while 32 British and 41 overseas students attended the Calder Operations School, which as more information on the operation of the Calder Hall reactors becomes available is increasingly able to provide a basic course of instruction for those who will ultimately operate similar types of reactor.

The Authority's staff again increased, from 27,290 on April 1, 1957, to 30,341 on March 31, 1958, the industrial staff increasing from 14,660 to 15,860, and reference may be appropriately made here to the Authority's arrangements for training its own staff. These continue to be developed in the light both of the White Paper on Technical Education and of the report of the Carr Committee. In particular, the Authority, which recruited 18 student apprentices and 150 craft apprentices during the year, is reviewing its arrangements in the light of the Carr report, in order to take advantage of the larger number leaving school during the next few years. Training schemes within the Authority, including full-time courses in laboratory techniques for junior staff, have been further expanded, and full-time degree courses in universities and sandwich courses at technical colleges continue to be awarded both to selected student apprentices and to selected members of the junior staff. Courses and management conferences for senior staff remain a developing feature of the Authority's training arrangements.

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* United Kingdom Atomic Energy Authority. Fourth Annual Report for the period 1st April 1957–31st March 1958. Pp. vi+68. (London: H.M. Stationery Office, 1958.) 4*s*. 6*d*. net.

This contribution to technological education needs to be kept in mind in considering the demands of the Authority under Britain's man-power resources, while the Authority's internal training programme has a decisive influence in removing what is probably the most serious limitation upon its plans to-day. It is apparent from this report, as from those of the Fleck Committees, how heavy is the responsibility that rests on the works manager and his team at the plant. It is no less apparent that the Authority is seriously short of first-class talent for promotion. Following the reports of the Fleck Committees, the Industrial Group has embarked on an intensive recruitment campaign to bring existing complements up to strength and to fill new posts resulting from the Committees' recommendations. Some of these posts have already been filled by promoting suitably qualified members of the Authority's staff, but the report admits a substantial margin of vacancies to be filled from external sources.

Now while the report quite rightly points out that it is still too early to assess the results of this recruitment campaign, it is fair to comment that there is unlikely ever to be an excess of staff of the high calibre and breadth of experience required for the most senior posts, and the Authority must look in the main for more managers from within its own ranks, and in fact from its own scientists and technologists, who alone are likely to possess the necessary technical qualifications or experience. Moreover, the shortage is not limited to the Industrial Group. There are probably more posts in the higher administration than there are trained men to fill them. The list of senior staff given in this report indicates that the place of deputy director of Aldermaston has not been filled since the former deputy director, Sir William Cook, took Sir Christopher Hinton's place as member for engineering and production.

It is clear enough from this report that the Authority is doing its utmost to increase its staff and to find the men required for the additional posts recommended by the Fleck Committees, though the setting up of the Committee with Sir Douglas Veale as chairman to advise on the training and provision of specialist health and safety staff for the Authority and the nation as a whole, represent in the first instance an increased demand on trained man-power. It will be remembered, however, that the Committee which considered the organization of certain parts of the Authority contemplated deliberate curtailment, if only temporarily, of some of the Authority's activities to enable the Authority to recruit sufficient staff of the high quality required, or to strengthen the technical staff at the levels indicated in the report. It is not apparent from the present report how far the Authority has considered such a reduction in its activities, in order that its programme would match the staff it has available.

Admittedly, there are possibilities that the responsibilities of the Authority may be covered by developments already in train. The new centre of nuclear studies should relieve the Authority of some of the purely physical research, and the universities should be able to do the same as the new equipment now being constructed comes into use. It is reasonable to expect that the relations with industry now being developed could do the same in the development of nuclear power for peaceful purposes; but if the possibilities are to materialize, a deliberate policy of shedding responsibility on the part of the Authority may be required. Some hint that this is being considered might well have been expected in the report, though it is noted that some research in controlled thermonuclear problems is also proceeding in the universities and in the laboratory of Associated Electrical Industries at Aldermaston.

So far as the actual development of nuclear energy is concerned, the report shows that the commissioning of the fast breeder reactor at Dounreay is regarded as less urgent than two or three years ago. The diversion of operating staff necessitated by the Windscale accident has extended the commissioning period, and the fast reactor will not become critical for several months after April 1, 1958, the original date. At Dounreay the Materials Testing Reactor is regarded as a much more urgent requirement, and Sir William Cook has stated that it will be three years before the place of the fast reactor in the hierarchy of industrial reactors can be assessed. Use of plutonium as fuel for fast reactors, in which it is most advantageous, will not be attempted for some time.

Meanwhile, it appears that the Authority's main hopes rest on a further development of the Calder Hall type of reactor, and its primary objective during the 1960's will be to realize the maximum potentialities of the gas-cooled, graphite-moderated reactor system. No further work is to be undertaken on the sodium-cooled graphite-moderated reactor system for the present. Technological and scientific knowledge, it is believed, are growing too rapidly to allow formulation of a firm long-term programme; but the present intention is to use beryllium-clad uranium oxide as fuel, although the reactor will be designed so as to allow alternative forms of high-temperature fuel to be tested on a large scale. The lower capital cost of this advanced gas-cooled reactor will offset the falling load factor which inevitably occurs as nuclear power supplies an increasing proportion of the nation's electricity; and it is possible that a scaled-down version of this reactor system might be suitable for merchant ship propulsion. The Authority is continuing to study the development of alternative systems, however, and by the 1970's work on the fast breeder system might have reached a stage at which commercial power stations can be built. The high-temperature gas-cooled reactor is also receiving detailed consideration as a potential reactor for nuclear power stations; but the prospects of commercial exploitation of energy from controlled thermonuclear reactions are for the future, and it is as yet impossible to suggest when a contribution to power supplies from this source can be expected.

This recent announcement by the Minister of Supply about plutonium adds interest and importance to the accounts of the processing plants in the Atomic Energy Authority's report, and the decision may well require greater effort at Capenhurst and elsewhere. Moreover, the prospects opened up by the successful navigation beneath the North Pole of *Nautilus* since the report was written might indeed lead to higher priority being given to the work on marine propulsion and possibly justify greater effort in that field. The Authority is already making an intensive study of the engineering design of a merchant ship, which should be complete in about a year; but even if this shows that a merchant ship powered by a nuclear reactor is likely to be economic, such a vessel could scarcely be commissioned before 1963 or 1964.

Studies so far made indicate that a scaled-down version of the Calder Hall type of reactor would be unsuitable for marine propulsion, except for very large vessels, and at present the advanced gas-cooled graphite-moderated reactor is being considered for this purpose as well as a gas-cooled reactor moderated with heavy water, while the organic-liquid moderated reactor system also offers possibilities of a compact system in which the containing vessel need not be capable of withstanding high pressure. Apart from any impetus which may be derived from the achievement of *Nautilus*—and for submarine propulsion the pressurized-water reactor system is particularly suitable—the reactors for marine propulsion, particularly the heavy-water moderated reactor, appear to have potentialities for small land-based power stations and hence for export purposes.

Considerable development effort will be necessary before economic reactors for these purposes can be produced, and the report points out that the diversion of scarce resources, technological skill and development effort cannot be justified until, for example, the prospect is seen of getting to sea a ship that is economic—or well on the road to that end. Nevertheless, the picture may have changed substantially since the report was written and planning permission for construction of the prototypes already granted. What matters, however, is the relevance of that effort not simply to the Authority's own staff and resources but also its relation to the nation's research effort as a whole. The main lesson which the Windscale accident has taught is that the Atomic Energy Authority must adjust its programme to the man-power which it can actually command; hence it is no less essential that the man-power which Britain can put at the disposal of the Authority should be determined with reference to other national needs.

The demonstration of the practicability of submarine polar navigation emphasizes the importance and urgency of one phase of the Authority's work; at the same time, it raises the question whether, when the fullest possible use is made of Anglo-American co-operation and the information which the United States can put at the disposal of Britain, it is not desirable that Britain should put some effort into research and development of the system of inertial navigation. In addition, however, while the Minister of Supply has recently told the House of Commons that the Ministry has been in constant touch with the Royal Society about the possibility of launching an Earth satellite, following his visit to the Woomera rocket range on August 7, Mr. Aubrey Jones has referred to the possibility of Britain undertaking a satellite programme using the Bluestreak long-range ballistic missile and the Black Knight high-altitude research rocket. Mr. Jones admitted that it would be unwise to make such an expensive diversion of effort unless it was warranted by the information that satellites would yield, and he asked the sensible question whether Britain really needs missiles of inter-continental range.

The further question should be asked whether the diversion of effort into the development of an Earth satellite could be justified. The Minister's remarks suggest that serious consideration is being given to a project which has been advocated, largely on grounds of prestige, for almost a year; but Britain can ill afford the diversion of scientific and technological resources, in equipment and materials as well as of man-power and finance, unless there are convincing reasons which would outweigh, for example, any consequent curtailment of nuclear development or research. To launch into such an undertaking except for the most convincing reasons of public interest could be wasteful extravagance.

Less concern might well be entertained over the prospect if there were not so little evidence that, both within the Authority itself and outside it, Britain's effort in the field of nuclear energy is being considered and planned in relation to the total resources of the country and the considered needs of other fields of scientific and technological inquiry and development. There is, on the contrary, much evidence of continuing piecemeal approach and action, and of this the Atomic Energy Authority's report provides further evidence in its silence about the siting of the future nuclear power stations. That is, of course, now the responsibility of the Central Electricity Generating Board; but the Authority might reasonably have been expected to comment on the working life of the nuclear power station. The realization that this is now expected to be no more than twenty or thirty years has deeply disturbed public opinion over the decision of the Minister of Power and the Minister for Welsh Affairs to approve the siting of a station at Trawsfynydd in the Snowdonia National Park and makes the haphazard and piecemeal siting of such stations intolerable.

Suitable sites for large nuclear power stations in Britain are not easy to find; but if such a power station is to be sited in a national park in a country so developed as Britain, there should be irrefutable evidence that the national interest will be grievously and irreparably damaged if the proposal is refused.

Moreover, the obstacles to placing the power station and its transmission lines underground should be made public; and if cost is the sole obstacle, that should be precisely known.

It is the failure to face the implications of a considered policy and to recognize that Britain's resources in finance, man-power, materials, equipment and amenity are limited and can be stretched too far, which is responsible for the concern over Government policy in regard to technological development. The Atomic Energy Authority's report supplies no evidence that the period of piecemeal action is ended. Accordingly it is necessary to reiterate that implementation by the Authority itself of the recommendations of the Fleck Committees alone will not suffice. If Britain is to reap the full benefits of the varied activities of the Authority—benefits which extend not merely into the medical field but increasingly, with the opening of the Wantage Radiation Laboratory, into such fields as industrial polymerization and the improvement of synthetic fibres and reduction of the immense loss of stored products through insect pests—it is not enough to bring the Authority's own programme and activities into balance with its resources in trained man-power. It is no less essential that the resources made available to the Authority are themselves in harmony with the other numerous and conflicting demands on the nation's limited resources of finance, materials, equipment and trained man-power.

MECHANICAL TRANSLATION

Mechanical Resolution of Linguistic Problems

By Dr. Andrew D. Booth, L. Brandwood, and Dr. J. P. Cleave. Pp. vii+306. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1958.) 50*s.*; 9.50 dollars.

Programming for an Automatic Digital Calculator

By Dr. Kathleen H. V. Booth. Pp. vii+238. (London: Butterworths Scientific Publications; New York: Adademic Press, Inc., 1958.) 42*s.*; 9.80 dollars.

THE second of these books is a companion volume to the former, and is essentially a programmers' handbook to the APEXC, the magnetic drum computer at Birkbeck College, London, which has been used for many of the experiments on language translation described by Dr. Booth and his colleagues. The book is not only a companion volume, of course, but also contains much information about how the more familiar processes of numerical analysis are programmed for a machine of this type. Thus, for example, the topics covered include input and output, division and square root, evaluation of functions by power series, floating point operations, solution of simultaneous linear equations, evaluation of latent roots, and finally, 'post mortem' checking programmes.

The first book deals primarily with language translation, although by way of introduction the authors include as "linguistic problems" various aspects of the investigation of literary style, such as lexicography, and the analysis of rhythm and syntax. For all these purposes the text has to be encoded and punched on teleprint tape (or other input medium) for scanning by the machine. The first four chapters describe how the machine can read and interpret information presented in this form. The question of stylistic analysis is discussed in relation to the problem of determining the chronological sequence in which Plato wrote his works.

In Chapters 5 and 6, there is a very good account of the general aspects of language translation, and the programming techniques used to overcome some of the difficulties. Thus it would appear that the first task is to construct a stem-ending dictionary so as to reduce the vocabulary to a manageable size, otherwise if all the inflected forms of every word were given the dictionary would grow to unmanageable proportions. The dictionary look-up process matches each word of the input text with a dictionary of 'stems'. When the stem has been located it is removed from the word and the remainder looked up in a dictionary of "endings". The two pieces of information derived from these dictionaries together give the equivalent of the input word. Naturally, variations of this procedure are necessary for a language in which inflexions are made by means of prefixes. Refinements of the matching procedure are also necessary in the case where the stem and ending are connected by redundant joining letters (as an example the authors consider some regular French verbs). To operate a dictionary in this case necessitates left-to-right matching to select from the stem dictionary the longest entry which is part of the input word. Once the stem has been removed, right-to-left matching is used to locate the ending. The remaining letters can then be discarded. A similar technique is used to deal with compound words, which are such a common feature of technical literature.

The dictionary search procedure which the authors recommend for an automatic computer is essentially the same as one would normally use, that is to say one opens the book (roughly) in the middle, and then proceeds to narrow down the entry in question by a partitioning process. By employing a binary subdivision process for this purpose a dictionary of N entries can be searched in approximately $\log_2 N$ matchings.

Other problems considered in Chapter 6 are connected with word order, idioms, multiple meaning and ambiguity. The problem of word order, for example, is to translate "équation différentielle est" into "differential equation is". A fairly simple procedure suffices in this case, to invert the order of adjective and noun, but in translating from highly inflected languages, where the relations between words is governed almost entirely by endings, more elaborate devices are necessary to ensure the appropriate rearrangement in the English equivalent.

Chapter 7 is concerned with the mechanical transcription of Braille, a problem which at first sight appears to have little to do with language translation. The difficulty, however, lies in the rules for forming *contractions*, where parts of words, such as 'con' and 'ion', are abbreviated to a single Braille symbol. While clear enough in their intention, they are not immediately suitable for programming because they cannot always be expressed formally in terms of the sentence structure, but depend very much on the context of the symbols the contraction of which is to be made; for example, they should not overlap well-defined syllable divisions. The authors conclude that the machine production of Braille text is not an economic possibility at present, in view of the large amount of voluntary effort available.

Chapter 8 describes an experimental scheme for translating from French into English devised for APEXC. For reasons of storage space the scheme was limited to a dictionary of 250 words and their English equivalents, but the programme was sufficiently comprehensive to perform certain operations of syntactical nature, and to recognize the masculine and feminine, singular and plural forms of nouns and adjectives, and also all parts of the verb except the first person imperative and the subjunctive mood.

The last part of the book is devoted to the translation of German, a subject which, unfortunately, the reviewer is not able to comment on.

The authors conclude by considering the technical details of a machine designed specially for translating. The principal feature of such a machine, of course, is a large high-speed store. Various special orders are recommended to facilitate the dictionary look-up process, and at the same time orders such as multiplication can be dropped. The authors suggest that such a machine could be built for between £50,000 and £100,000 but are rather sceptical of obtaining financial support on this scale. However, their proposed instruction code for a linguistic machine is not so very special, and it would scarcely seem worth while to build a machine on this scale which would exclude it from doing tasks other than language translation. The authors' best hope, therefore, lies in the super-high-speed computers at present under development, such as Stretch or Larc.

R. A. Brooker

WORK ON FUSED SALTS

Soviet Research in Fused Salts (1949–1955)

(Chemistry Collection, No. 1.) General. Pp. 28. Structure and Properties: Ternary Reciprocal. Pp. 200. Structure and Properties: Quaternary Systems; Quaternary Reciprocal Systems. Pp. 98. Structure and Properties: Preparation; Iodine Systems. Pp. 156. Structure and Properties: Binary Systems: Ternary Systems. Pp. 284. Slags and Mattes. Pp. 39. Electrochemistry. Pp. 54. Thermodynamics. Pp. 58. Translated from the Russian. (New York: Consultants Bureau, Inc.) n.p.

Interest in the structure and properties of fused salts has been growing with noteworthy vigour in the past few years in various countries. From the fundamental point of view, molten salts constitute a distinct class of fluids, with an extensive range of temperatures over which the liquid state may be stable, with high heats of vaporization, and with quasi-crystalline structures in which the tendency for an ion of one sign to be preferentially surrounded by ions of opposite sign imposes an additional element of order, compared with other liquids. Despite the technical difficulties to be overcome, these characteristic properties have stimulated various basic researches on the transport and thermodynamic properties of ionic melts, and on melting mechanisms of ionic crystals.

The very great importance of fused salts in electrometallurgy, particularly of the more electropositive or reactive cation-forming elements, has for many years prompted applied research the bulk of which greatly exceeds the body of fundamental studies available in published literature. Much of this research is somewhat empirical. In addition to their interest for electro-metallurgy, fused salts have many analogies with fused silicates used as slags in bulk production of various metals. Their physical properties for applications as heat transfer fluids and bath fluids are also attracting increasing attention. All these considerations make any additions to published research, especially on the fundamental properties of fused salts, particularly welcome at the present time. Unfortunately, for many Western scientists researches published in Russian must still be regarded as not freely available until translations become accessible. The appearance of this collection prepared by the Consultants Bureau Inc. can therefore be described as very timely.

Translations necessarily suffer from certain defects in reproducing new knowledge. For example, the present collection includes nearly one hundred papers on melting and phase relationships for binary, ternary and quaternary mixtures of salts. The curves by means of which much of this information is recorded suffer in precision through the process of reproduction; such records may not be sufficiently accurate or clear for some purposes. However, it is very useful to know even the approximate shape of the diagrams in many cases.

In addition to a great bulk of work on phase diagrams, a limited number of the papers included give calculations on activity coefficients from electromotive force data, on the surface tension, density, viscosity and electrical conductivities of melts, on corrosion of metals by melts, and on slags.

Though discussions of basic theoretical considerations are included in some of the papers, the inspiration of much of this work appears to be technological. It constitutes an extensive body of factual knowledge about fused salts which should prove useful to those who do not have access to the original publications.

A. R. Ubbelohde

SOCIAL MEDICINE

The Teaching of Hygiene and Public Health in Europe

A Review of Trends in Undergraduate and Postgraduate Education in Nineteen Countries. By Prof. F. Grundy and Prof. J. M. Mackintosh. (World Health Organization: Monograph Series, No. 34.) Pp. 254. (Geneva: World Health Organization; London: H.M. Stationery Office, 1957.) 15 Swiss francs; 25*s.*; 5 dollars.

During the past hundred years scientific methods have been applied widely in medical research and practice; in the same period the health of the population of the Western world has improved. But the improved health owes less to advances in medical science than to changes in the external environment, and a favourable trend in the standard of living. We are healthier than our ancestors not because of what happens when we are ill but because we do not become ill; and we do not become ill not because of specific protective therapy but because we live in a healthier environment. In its preoccupation with the minutiae of diagnosis and the pathogenesis of disease, medicine is in danger of neglecting what has hitherto proved its most powerful resource—the manipulation of the external environment—and of failing, when it can do no more, "au moins à nous mener à la fin de la vie par un chemin agréable".

These are among the considerations which have led to an attempt to improve the teaching of preventive and social medicine, and the report prepared for the World Health Organization by Prof. F. Grundy and Prof. J. M. Mackintosh provides a valuable account of the instruction given in the medical schools of Europe. They describe briefly the curriculum in different countries, and interpret the trends in undergraduate and postgraduate teaching. Perhaps the most obvious conclusion suggested by their report is that there are still wide differences of opinion about what is needed. In Oslo and Amsterdam it is considered desirable to have two separate departments of hygiene and social medicine, and this pattern is soon to be extended to Sweden. In London no medical school has a chair of social medicine, and instruction is entrusted to part-time teachers or to other departments.

There are equally wide differences of opinion about the interpretation of the subject itself, for while the concept of social medicine evidently means a great deal to many people, it does not always mean the same thing. To the original core of traditional public health teaching have been added a number of other subjects—medical administration, medical statistics, human genetics, demography, social biology etc.—some of which have little more in common than the facts that they are obviously important, and either are not taught or are inadequately taught by any other department. Indeed social medicine has come to be identified with almost any medical theme which is statistical in its method or social in its implications; it is scarcely surprising that the syllabus which has resulted is overweighted and lacks coherence. As Grundy and Mackintosh recognize, if the subject is to make its full impact on medical education there will have to be some contraction of its ill-defined terms of reference, with, one would add, a synthesis of the material which remains.

THOMAS MCKEOWN

POLES, NORTH AND SOUTH

Arctic and Antarctic

A Prospect of the Polar Regions. By Colin Bertram. New edition, entirely revised. Pp. ix+123+13 plates. (Cambridge: W. Heffer and Sons, Ltd., 1958.) 21*s*. net.

NINETEEN years ago, in the preface to the first edition to this book, the author wrote, "The idea then came to me that it might be worth while attempting, not to record the narrative of an expedition, but to state some principles, physical, physiological and psychological, which govern the life of men in polar lands, presenting them in a way which might be of interest to others than specialists. When the attempt was made to follow out this plan, it soon became obvious that the underlying principles of dietary, housing and transport could be far more attractively presented in a setting that depicted the life itself". The result was a new type of introduction to the polar regions. It was based on wide reading and personal experience in both the Arctic and the Antarctic, it gave an enormous amount of information in a few pages, and it was well written. Now, with the added qualification of seven years as director of the Scott Polar Research Institute, Dr. Bertram has brought out a second, and greatly revised, edition of his book.

The history of polar exploration he divides into three stages: the pioneer stage before the First World War, the intermediate stage between the World Wars, and the present modern stage. The progress from stage to stage is "largely to be measured in increasing complexity and enlarged material resources. The simple motive of personal high endeavour . . . has been transformed into national political aspirations".

He begins with a general survey of the polar regions and the animals, birds and fish on which travellers there may exist. Few species occur in the Arctic, and still fewer in the Antarctic, but such as there are congregate in numbers seldom seen in the rest of the man-infested world. Insects and penguins are as numerous as ever, but other species have been all but exterminated at one time or another by man for economic gain, and only survive now through protective legislation. Then the main aspects of polar life are taken in turn and their progress through the three stages, pioneer, transitional and modern, is examined; they are physiology, acclimatization and clothing, dogs, transport, food, organization and leadership. These chapters contain so much that is interesting that extracts are impossible; certainly one would need to be a voracious reader to collect all these facts elsewhere.

Dr. Bertram's long and varied experience of polar affairs makes his appreciation of the "Polar prospect to-day" particularly valuable and interesting to anyone concerned with these regions. The International Geophysical Year of 1957–58 he sees as a turning point in Antarctic history. In spite of the scientific motives that have taken so many nations south there is little doubt but that political changes will result. New sovereign areas, agreed spheres of influence or internationalization, each is possible; all that the author feels certain is that "political factors will largely prevail over the claims of international law as at present understood".

It is a pity that this book has appeared so late in the recent stream of polar books, and may meet with undeserved neglect on this account.

L. M. FORBES

HOW NEUTRONS GET THERE

Neutron Transport Theory

By B. Davison, with the collaboration of J. B. Sykes. (International Series of Monographs on Physics.) Pp. xx+450. (Oxford: Clarendon Press; London: Oxford University Press, 1957.) 75*s*. net.

IN the construction and the performance of nuclear reactors, problems connected with the movements and distribution of neutrons inside the reactors are of prime importance. Some of these problems were solved even before neutrons were discovered, in the setting of astrophysics. The current theory of neutron transport pays due homage to this venerable parentage by much of its terminology and techniques. On the other hand, young as the subject is, it has already outgrown its ancestry by the subtlety and variety of the problems and the demand for the great accuracy in the solutions. Most of the (published) progress of the subject dates from the later years of the Second

World War and onwards; the author of the book under review has a distinguished and well-known record in that progress. He has now produced in a massive and carefully written volume a fine account of the various mathematical methods which have so far been brought to bear on the problems of neutron transport. In his task he received the active co-operation of a number of eminent specialists in the field. Readers who approach this subject with experience in some other branch of physics will be interested, possibly surprised, to read in the book the contributions to transport theory by physicists (for example, Feynman, Fuchs, Pryce) more widely known in other fields.

The book starts with a general statement of the problems involved: this may be equivalently framed either as the Boltzmann equation or as an integral equation. In the greater part of the rest of the book various solutions, analytical and numerical, are considered. The reader is left in no doubt as to which method to apply in a particular situation. The ordering of the treatment is, quite appropriately, to take simpler problems first and consider others in an order of increasing complexity. The result is that roughly the first one-third of the book is 'compulsory reading', after which various sections in the remainder are independent of each other. The intention of the author to make the mathematical treatment detailed and self-contained has been achieved with remarkable feats of economy.

The book is primarily directed to the advanced worker in neutron transport theory. To him the book offers mainly the following three advantages: the opening chapters contain a balanced and precise justification for the physical assumptions of the theory. Secondly, by presenting the subject as a systematic and compact discipline this book promises to be a standard one, as regards form and notation, and as regards the inter-relation of topics treated in the book. Lastly, much of the material is published in this book for the first time.

This book can be strongly recommended to those interested in other branches of transport theory. It is not always that the methods developed in connexion with neutrons can be legitimately applied; nevertheless, there is a great deal to be gained from familiarizing oneself with these methods.

It is a pity that the book makes scarcely any reference to the way in which these elaborate calculations have been tested or put to use. Now it may seem misguided to ask for this kind of information, much of which is probably not at the author's disposal, in what is primarily a text-book of methodology. Nevertheless, one hopes that future circumstances will enable the author to make allowance for a (proverbially deadly) weakness of his reader.

R. Englman

MINERAL REQUIREMENTS OF PLANTS AND ANIMALS

Mineral Nutrition and the Balance of Life

By Dr. Frank A. Gilbert. Pp. xv+350+30 plates. (Norman, Oklahoma: University of Oklahoma Press, 1957.) 5.95 dollars.

Animal and plant physiology have an important link in the mineral nutrition of the plant. Many instances are now known, and others are constantly coming to light, where a deficiency in a food plant has important consequences on animal health. These discoveries have led to greater emphasis on the problems of interrelationships between plant and animal nutrition, and this in turn has intensified investigations on the mineral content of soils of different localities. It is perhaps not surprising that nutritional disorders of animals due to deficiency or excess of minerals were not immediately associated with the mineral composition of the food plant because elements essential to animals are not necessarily essential to plants, and the latter have the facility of accumulating elements which take no part in metabolism but have no harmful effects on their growth. Thus, cobalt is not considered essential for higher plants but the small amount that occurs in plants is of great importance because normally this is the only way in which animals get their essential supplies of this element. Some plants are tolerant to the presence of selenium in the soil, but such plants are toxic to animals.

The story of mineral deficiencies in plants is in itself a fascinating one and Dr. Gilbert has not only given a very complete account of the mineral requirements of plants but also linked it with the question of nutrition and well-being of animals that use these plants as food. The treatment of this subject may be said to be comprehensive since the author considers each element in turn, first from a historical point of view and then how the lack (or in some cases excess) of that element affects plants and animals, including humans. These accounts are linked to the relation between deficiencies and the soils of particular localities with mention of the geographical regions where deficiencies prevail. It is inevitable that most of the latter information refers to the North American continent, where the most intensive work has been done, but available information from other continents is included.

So far about sixty elements have been identified in plants, but only about twenty of these are conceded to be essential either to plant or animal nutrition. The present book, however, deals with thirty-one, including not only the major elements nitrogen, phosphorus, potassium, calcium and magnesium and the trace elements but also others such as aluminium, silicon, selenium, fluorine, arsenic and lead which are of interest by virtue of their toxic properties.

The author has included a chapter on enzymes, hormones and vitamins which seems out of place in a book of this nature. The brief chapter on analytical methods underlines the fact that the book is not primarily addressed to the specialist although there is much in the book which is of interest to those concerned with mineral nutrition and the 1,177 references are a valuable guide to the literature, but by no means exhaustive. The book concludes with a chapter on human nutrition which repeats the main theme of the book that the health of the animal depends on a supply of nutritious forage. The author points out that we are protected by law against harmful drugs but not against inferior food, and pleads for more education and publicity to create a realization of the need for better quality food.

The book is well produced and contains numerous photographs illustrating symptoms of mineral deficiency and toxicity in plants and animals. It can be recommended as a good general account of the mineral requirements of plants and animals.

E. C. Humphries

Selected Combustion Problems, 2

Transport Phenomena; Ignition; Altitude Behaviour and Scaling of Aeroengines. M. W. Thring (Senior Editor). (AGARD Combustion Colloquium, Liège, Belgium, December 5 to 9, 1955.) Pp. viii + 495. (London: Butterworths Scientific Publications; New York: Interscience Publishers, Inc., 1956.) 90*s.*; 12.50 dollars.

THIS is the record of the combustion colloquium, held at Liège in December 1955. Eighteen papers were presented and discussed at some length, the languages used being English and French. Abstracts are rendered in both tongues with occasionally interesting results, and a small subject index of doubtful value is appended.

The papers are, as the main title of the book suggests, on chosen aspects of combustion. The choice naturally has regard to the interests of aeronautical scientists, and the sub-title rather incompletely indicates group headings. The author's aim is generally to survey, and little new experimental work is presented.

There is no doubt that colloquia of this nature are of value in assessing the current state of knowledge and in defining those problems that most clearly call for study. It is good to see evidence that time was allowed for extended discussion.

As to how far the record is of permanent value on the library shelf is another matter. A possible view is that the practical success of the meeting will be measured by the speed with which the papers and discussion become out-dated. Meanwhile, those who are concerned with aero engines (including rocket motors) and their fuels, fundamentally considered, will find ample material for consideration within these pages. J. H. Burgoyne

The Alimentary Tract of the Ruminant

By David Benzie and Dr. A. T. Phillipson. Pp. 24 + 54 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 27*s.* 6*d.* net.

INVESTIGATION of the gut of the ruminant during the past twenty years has made the chemical changes which go on within the stomach reasonably plain. This is not, however, true of the mechanical activity of the alimentary tract and there is still a considerable degree of doubt as to the way in which food is sorted into that fraction which goes to the rumen and that fraction which is passed along the œsophageal groove to the abomasum, and as to the muscular movements which play a part in the belching which these animals use in order to get rid of the gas produced during ruminal digestion. A relatively new approach to these problems has been made with the use of radiographic studies, a series of which is reported in this volume. Part of the work was done in the Department of Physiology of the Rowett Research Institute, and part in the Department of Anatomy at the University of Manchester. The animals appear to withstand the effect of radiography well and not to be much affected by this experimental method. The book consists largely of an atlas of 54 plates, most of which contain several X-ray photographs of the alimentary tract of young animals (lambs, calves, kids) fed a barium meal. The movements of the gut are obviously complex, but among the interesting points which the series of photographs makes plain is the confirmation of the extra-ruminal contraction described by Weiss as the basis of the belching mechanism. Since the work was carried out predominantly on young animals mainly fed on milk, the part played by the chambers of the stomach other than the abomasum is not made plain, though an interpretation of the activity of the omasum is given. There is every expectation of this most promising method leading to clarification of the muscular movements carried out by each part of the stomach in the alimentary tract of these animals. A. Graham

Structural Psychology

De Humani Mentis Fabrica. By D. and K. Stanley-Jones. Pp. viii + 180. (Bristol: John Wright and Sons, Ltd., 1957.) 21*s.*

THE authors of this book define structural psychology as "a system of psychology erected upon the basic sciences of anatomy and physiology" (page v) and further state that "the contribution which structural psychology has to make to the major problem of philosophy has been to prove that the structure of the mind and the structure of the brain are sufficiently alike in every known point of comparison to warrant the statement that they are identical. By proof of the identity of structure the hypothesis is justified that there is an identity both of location and substance" (p. 160).

It is suggested that emotion originated in palæolithic times when man lived mainly in caves, and these were conditioned to "lust and feeding in the warmth of the night, aggression in the outside cold of the day". Aggression is associated with oral biting and massive discharge of the orthosympathetic system, and in balanced antagonism with oral sucking and the parasympathetic system. Obstruction of the sucking leads to a mass discharge of the orthosympathetic with oral biting.

These basic reactions become associated with the mother, envisaged by the child as the bad mother when it is unsatisfied and the good mother when it is. From her the emotions are transferred to the father and so to society.

It is impossible to describe the whole of the authors' arguments in a few words. They link physiology ingeniously with psychological concepts, but their system is not completely new and is mainly a fresh arrangement of Freudian psychology and organic theories. It should prove interesting to those psychologists interested in physiology and those physiologists psychologically orientated.

The book is clearly printed on non-shiny paper, the style is lucid and should be understood by educated readers even if unfamiliar with the material. There is an excellent index and glossary.

Intermediate Physics

By Dr. C. J. Smith. Fourth edition. Pp. xiii + 1322. (London: Edward Arnold (Publishers), Ltd., 1957.) 45*s.* net.

OVER some twenty-five years the successive editions of this standard intermediate text-book have proved their value. There are 300 more pages than in the 1947 edition, and the extensive re-writing to clarify points which students always find difficult, with the addition of material to bring it well up to the requirements of a good scholarship candidate, will certainly increase even further the number of people who will use it happily and with success. Noteworthy additions are the fuller treatment of

RADIATION

Čerenkov Radiation

By **J. V. JELLEY,** B.SC., PH.D., *Atomic Energy Research Establishment, Harwell*

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By **G. J. NEARY, R. J. MUNSON,** *and* **R. H. MOLE,** *Medical Research Council Radiobiological Research Unit, A.E.R.E., Harwell.*

This monograph reports the results of an investigation of the biological effects of chronic irradiation, in which mice were irradiated with fast neutrons up to normal life span. Full biological and physical details of the experiments are given, including a discussion of the dosimetry. The results include data on survival, body weight, pathology, haematology, organ weights and fertility. This is an important book for all concerned with aspects of nuclear energy and the biological sciences, as well as medical workers concerned especially with radiotherapeutics.

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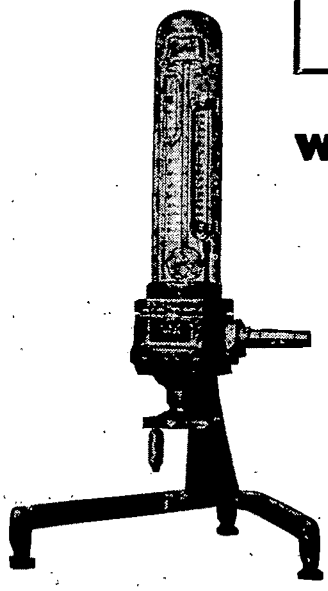

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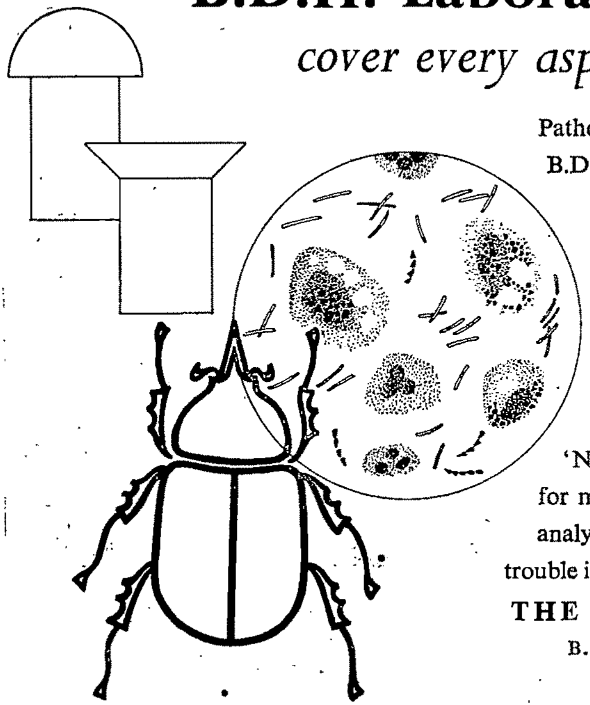

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dynamics and of the experimental side of electrostatics, and a chapter on forced vibrations and resonance in the section on acoustics. There are also many more numerical examples for solution.

Dr. Smith holds strong views about the MKS system, which one gathers he would not touch with a pole; and his comment on units in the preface may seem a little sweeping. His mastery of the orthodox approach in the sections on electricity, and the general excellence of its presentation, nevertheless compel one's admiration. G. R. NOAKES

Principles of Engineering Heat Transfer

By Prof. Warren H. Giedt. Pp. xiii+372. (Princeton, N.J., and London: D. Van Nostrand Company, Inc., 1957.) 48*s*. net.

IN view of the extensive literature of the subject, the number of text-books on heat-transfer is surprisingly few and makes this new addition especially welcome. The author has rightly devoted the major part of the work to a fundamental exposition of the basic principles, avoiding embroilment in the jungle of empirical data which has grown up with the development of this subject. The book follows the natural division of heat-transfer into the three modes of conduction, convection and radiation, all of which are treated with admirable clarity. The order of treatment is, however, somewhat unusual, the separation to opposite ends of the book of the chapters on steady-state and transient conduction appearing to serve no useful purpose. The relegation to the last chapter of the concept of logarithmic mean temperature difference, which is so fundamental in the study of heat-exchange equipment, is also a less desirable feature of the book. Convection is preceded by two chapters on fluid flow which in the main are most helpful to an understanding of convective heat-transfer principles. There are, however, certain superfluities for a book of this kind, the most noticeable of which is the inclusion of the elementary theory of orifice and venturi meters.

Among the commendable features of the book are the summary of the principles of the heat and momentum transfer analogy in the solution of turbulent convection problems, including the extension to the special problem of liquid metals, and the description of electric analogue methods in the solution of conduction problems.

The book will be extremely useful to the student at university degree-level but would have been improved by the inclusion of numerical answers to the many end-of-chapter problems, a deficiency which, alas, is a common failing of almost every text-book of American origin. H. COHEN

Die Bluteiweisskörper des Menschen

Untersuchungsmethoden und deren klinischpraktische Bedeutung. Von Prof. Ferdinand Wuhrmann und Dr. Charlie Wunderly. Dritte völlig umgearbeitete Auflage. Pp. 499. (Basel und Stuttgart: Benno Schwabe and Co., 1957.) 52 Swiss francs.

THE previous two editions of this treatise, published in 1947 and 1951, were, perhaps, much better known on the Continent than in Britain because no English versions were available. This edition is an extensive revision and enlargement of the former editions. A welcome feature is the prominence now given to paper electrophoretic and agar gel immuno-electrophoretic techniques. Here, at last, is a book which brings together so many illustrations of abnormal plasma protein patterns. Another feature is the thorough discussion of the traditional techniques of free electrophoresis, ultracentrifugation and salting out. Routine clinical methods for blood examination are also well covered; the clinical significance of the plasma proteins, their evaluation and their alteration in disease are comprehensively discussed.

There is a tendency, perhaps understandable, to refer more to German than to non-German sources, but consequently some important work is overlooked or not given the attention it deserves. Recent techniques of zone electrophoresis in columns or slabs or of ion exchange chromatography are not mentioned though they have been used with striking success for plasma protein separation. In such a detailed book the subject index might perhaps be fuller. However, there is a good balance between the physico-chemical and clinical sides and in this respect the book is exceptional. Each of the authors is a specialist in each field and they have collaborated for many years in clinical investigations. Though rather expensive the price is not too high for such an attractively printed, comprehensive reference work. Its appeal would undoubtedly be widened if an English version was available. R. CONSDEN

Selected Lectures in Modern Physics for School Science Teachers

Edited by Prof. H. Messel. Pp. 168. (Sydney: Nuclear Research Foundation within the University of Sydney, 1958.) 30*s*.

IN January of this year the Nuclear Physics Foundation of the University of Sydney held a summer school for science teachers. This was not just a refresher course to attack or remove the outer layers of rust. Its expressed intention was to infect the participants with an inspiration which they would spread, and the direct aim a second-order effect on the future entrants to the faculties of science and engineering. This record of the proceedings, which was made available at the end of the school (in itself a remarkable feat of publishing), is both a worthy tribute to the venture itself and an excellent survey of many fields of modern physics.

The twenty-four lectures range widely, and the topics seem to have been chosen for their general interest; they are the matters on which a teacher would very properly be expected to be able to answer questions. Nuclear energy; low-, high-, and ultra-high energy nuclear physics; 'strange' particles; physics in rain-making; Newton's laws of motion and space-travel; radioastronomy; how to talk to an electronic brain; transistors; the use of isotopes in medicine; physics in geology; measurement; and cosmic radiation; these are among the main subjects selected. There are also an instructive account of the building of relatively simple apparatus for demonstration experiments in electronics and nuclear physics, and a discussion of careers in physics, and of the need of suitable candidates for them.

The lecturers themselves are to be congratulated on touching just the right level for their audience, and on communicating their obvious enjoyment of their work. I learned a great deal from the book, felt that I understood most of it, and was much impressed by the way it was all presented. The book can be highly recommended to teachers of science, and will be a most valuable acquisition to a school science library. G. R. NOAKES

THE LYOT $H\alpha$ HELIOGRAPH AT THE CAPE OF GOOD HOPE

By DR. M. A. ELLISON

C.S.A.G.I. Reporter for Solar Activity, Royal Observatory, Edinburgh

THE organization of the International Geophysical Year has provided a splendid impetus to the study of solar-terrestrial relations. Quite early in the planning stages it was realized that the solar chromosphere must be kept under continuous observation throughout the eighteen months. This meant the provision of equipment, well distributed in longitude and located in the most favourable climates, which would automatically photograph the Sun in hydrogen light at 1-min. intervals. In addition, the observing periods at existing stations, equipped with visual spectrohelioscopes, had to be planned in advance on a time basis so as to fill in the gaps and avoid duplication[1].

This organization has become known as the 'solar patrol'. Some 25 stations are now filming the Sun, and by their combined efforts it is hoped that no solar activity which may be of significance in the study of the ionosphere, geomagnetism, cosmic rays or solar radio emission, will pass unobserved.

In the middle of 1955, the British National Committee for the International Geophysical Year decided to make a substantial contribution to the work of the solar patrol. A sum of £17,000 was voted for the provision of a Lyot-type heliograph along with some auxiliary apparatus and the building to house it. The site chosen was the Royal Observatory, Cape of Good Hope, where under Her Majesty's Astronomer (Prof. R. H. Stoy), expert staff and maintenance facilities would be available. The sunshine hours at the Cape average 68 per cent of possible, compared with some 40 per cent in the most favourable part of the British Isles. For many years the Cape Observatory has contributed daily photographs of the Sun in white light to the Greenwich photoheliograph programme; and in 1949 the Sun was photographed at the Cape on 360 days.

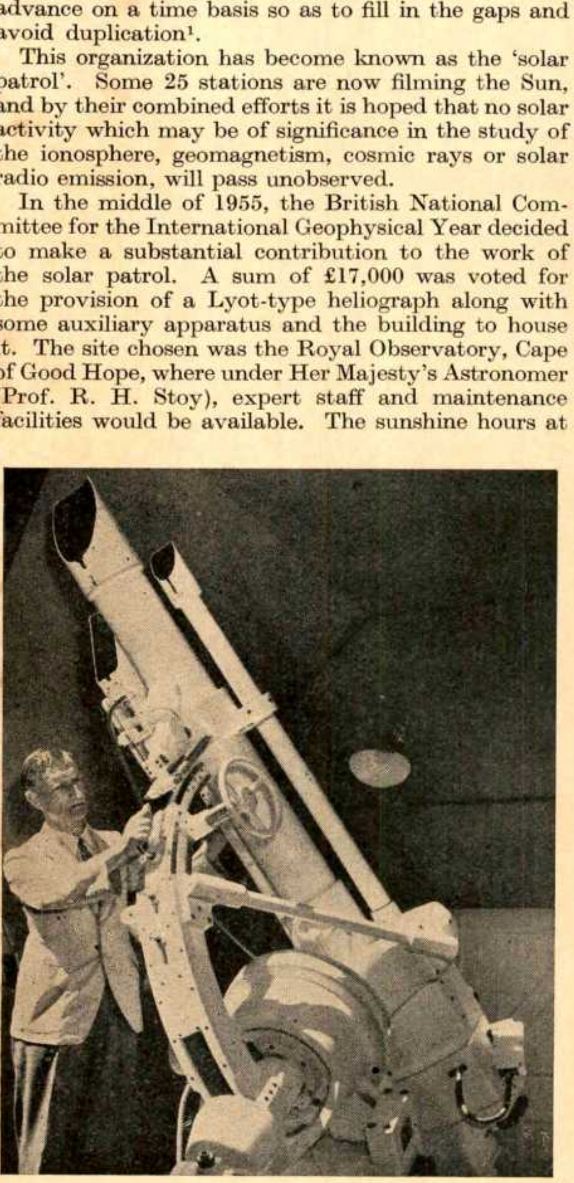

Fig. 1. Lyot $H\alpha$ heliograph installed at the Royal Observatory Cape of Good Hope

The contract for the construction of the heliograph was placed by the Admiralty with the firm Société d'Études et de Construction d'Appareillages Scientifiques et Industriels of Bordeaux in December 1955. The completed instrument was accepted there in November 1957 and delivered to the Cape on February 25, 1958. After successful tests of the optics and electronic circuits, it was brought into daily operation on March 16.

We owe the original conception of the monochromatic heliograph to the late Bernard Lyot. After his lamented death in 1952, the plan was brought to a practical outcome by the construction of a prototype instrument at Meudon, chiefly through the labours of the d'Azambujas and Dr. A. Dollfus. The production on a commercial basis was undertaken by the Société d'Études et de Construction d'Appareillages Scientifiques et Industriels, the study group of which was responsible for the equatorial mounting, the electronic and electro-mechanical arrangements, as well as the auxiliary and cinematograph optics. The main objective and the monochromatic filter were constructed by the firm Optique et Précision de Levallois.

The instrument comprises three separate optical trains. In the centre (Fig. 1) is the monochromatic telescope, consisting of an objective of 14 cm. aperture working at f 10. The beam from this lens traverses two glass prefilters before being rendered parallel for its passage through the Lyot filter. This filter is of the standard design[2], being built up of eight birefringent plates of quartz and others of calcite with intermediate 'Polaroids', all contained inside a cylindrical block of aluminium. The temperature of the block is thermostatically controlled so that at the working temperature of the filter (44·2° C.) the band pass of 0·7 A. is maintained precisely fixed upon the centre of the $H\alpha$ line (6562·8 A.). On emerging from the filter, the monochromatic beam is focused on the film frame of the camera placed in the breech of the telescope and forms there a solar image 15 mm. in diameter. Exposures are made on standard 35-mm. film; using Kodak Panchromatic Microfile emulsion, the normal exposure time is 2 sec. The duration between exposures may be pre-selected for intervals of 60, 30 or 15 sec. By the operation of a uni-selector switch every eleventh frame receives an exposure time five times normal. This has the effect of over-exposing the disk so as to record only the prominences at the Sun's limb. An eye-piece conveniently placed at the side of the camera allows the image in $H\alpha$ to be observed visually in the intervals between exposures.

The second optical train (right-hand tube of Fig. 1) is that of the electronic guider and exposure meter. The main drive to the equatorial in right ascension is provided by a synchronous motor which operates

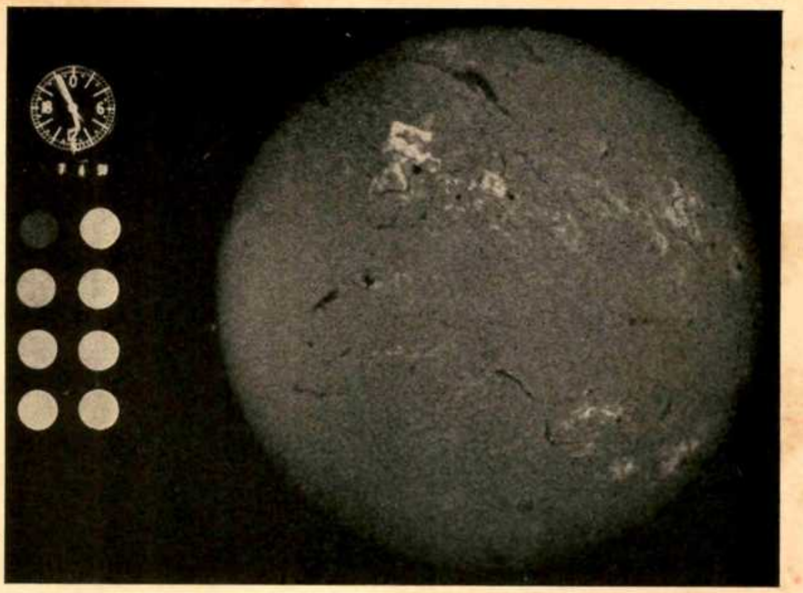

Fig. 2. Heliograph exposure, April 7, 1958, 10h. 55m. 54s., showing a Class 3 flare in operation. Normal sky orientation

through the usual reduction gear, worm and driving wheel. The electronic guider compensates for all errors in the main drive, for maladjustments of the polar axis and for refraction changes at varying altitudes. The image to be photographed is thus maintained centred in the film frame with an accuracy of 1–2 sec. of arc —an important feature when the films are to be examined later with a cinematograph projector.

The lens system of the guider forms a solar image about 1 in. in diameter. This image illuminates a wide slit tangential to the east limb together with a circular hole placed some distance inside the west limb ; the slit has an aperture twice the area of the hole. When the light flux through each is the same, the photocells behind receive equal illumination and their currents cancel one another. An excess of current in either direction, due to a lateral shift of the image, operates a symmetrical valve amplifier the output of which affects a magnetic amplifier with two stages. This, in turn, operates in either sense the diphase motor of the right ascension slow-motion. A similar arrangement of apertures and photocells, placed at right angles to the former pair, corrects for errors in declination. Such a system has the added advantage that it functions independently of the seasonal variations in the apparent diameter of the solar image.

In the same optical system the centre of the solar image illuminates a small aperture behind which is placed a fifth photocell. This cell acts as a photometer and regulates the duration of each exposure. The start of the exposure is obtained by applying a negative charge to the condenser of a light-integrator, which, by means of a valve $6AK5$, releases the trigger of the camera shutter. The condenser is progressively discharged by the cell of the photometer. When the condenser has discharged, the same valve again becomes conducting, pulling the shutter trigger and terminating the exposure. The exposure-times are thus proportional to sky opacity, which means that the resulting solar images on the film are of nearly uniform density, a most important feature for accurate photometry.

When thick cloud intervenes, a 'no light' relay comes into operation, switching off the camera action in order to conserve film. As the sky clears, the image is automatically re-centred and the operating cycle begins again.

The third optical system (to the left of the main tube in Fig. 1) serves two purposes. First, it contains a clock and calendar which are illuminated by diffuse sunlight. The clock is set to Universal Time at the start of each day's run, and its image, focused on the film by means of a lens-cum-prism train, records the time and date of each exposure (Fig. 2). Secondly, an echelon of eight circular spots is focused below the clock in order to provide a photometric calibration. The echelon is formed of eight blocks of neutral glass, each having been ground and polished to a suitable thickness so as to provide density steps of 0·1. These blocks are uniformly illuminated by direct sunlight which has previously traversed a red filter and an opal diffusing screen. Thus the quality of the light forming the calibration image on the film is similar to that of the solar image, while the exposure-time is the same for both whatever the transparency of the sky.

The equatorial mounting is of unusual design, having been planned with a short polar axis and a wide fork to combat the effects of flexure and wind vibration. Rising from the lower end of the polar axis are two telescopic arcs of radius 80 cm. which are concentric with the declination axis. The extension of these arcs by means of a rack and pinion provides for the seasonal variations of ± 23° in declination. The inner arc carries at its head the diphase motor and screw of the declination slow-motion, the upper end of the telescope tube being held in contact with the screw by means of two extensible springs. The telescope thus receives support from the three angles of an isosceles triangle.

A control cabinet for the instrument houses under damp-proof conditions the filter thermostat, the time-relays for operating the exposures and all the electronic and electro-mechanical parts. Controls are effected by press-buttons on the front panel, where indicator lamps also enable the operator to judge the correct functioning of the various circuits. Experience gained at the Cape fully supports the claim for automatic operation. Apart from the routine procedures of setting on the Sun, regulating the clock and loading the film cassettes, it performs its daily run without further attention until close-down. The roof of the building has been so constructed that a clear aperture extending across the sky is available at all seasons.

The films taken with the heliograph (about 25 ft. per day) are being developed at the Cape. They are then dispatched to the Royal Observatory, Edinburgh, where they are projected and examined for the occurrence of flares and blow-off prominences, the records of these phenomena being contributed monthly to the International Geophysical Year World Data Centres. The images on 'Microfile' film can be enlarged to a diameter of 6 in. before the film grain becomes noticeable ; and on this scale they show considerably greater resolution of fine detail than the best spectroheliograms.

The high performance of the filter is also illustrated by the low intensity of the scattered light. On a day of moderate sky transparency, the scattered light (sky plus instrumental) at a distance of 2 min. of arc outside the solar limb was measured as 3 per cent of the intensity of the central disk. With most spectrographs the scattered light would have five times this value. On the other hand, the intensity at the centre of the disk in the $H\alpha$ image was found to be 28 per cent of the intensity of the continuum outside the wings of $H\alpha$. This is high compared with the known value of 15 per cent for the centre of the $H\alpha$ line ; it arises from the relatively wide band-pass of the filter (0·7 A.), which causes it to transmit appreciable light from the line wings.

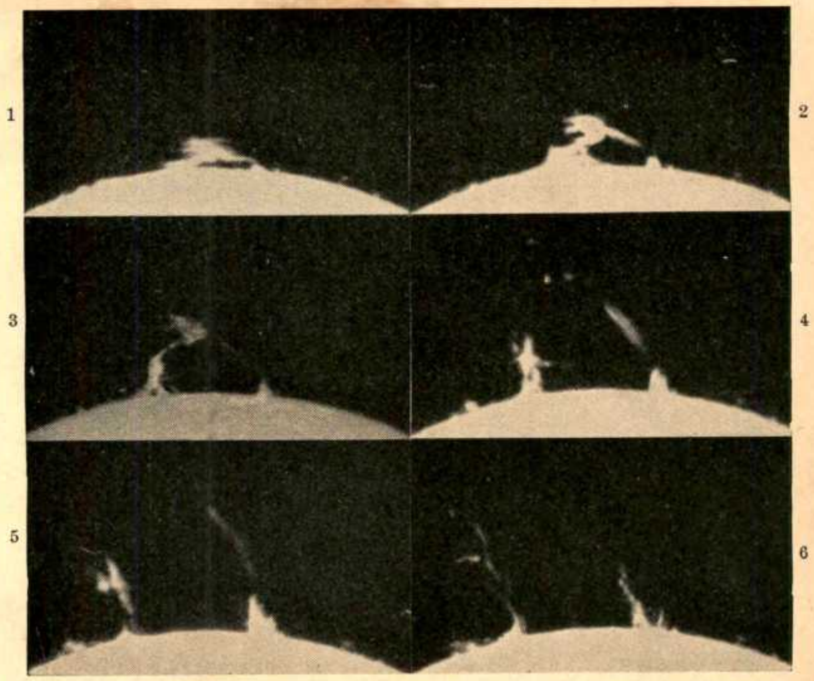

Fig. 4. Blow-off prominence on the west limb, March 14, 1958. Times: (1) 14h. 39m. 10s.; (2) 14h. 50m. 15s.; (3) 14h. 54m. 15s.; (4) 14h. 58m. 25s.; (5) 15h. 01m. 25s.; (6) 15h. 04m. 25s.

One of the most important investigations to be undertaken with the Lyot heliograph will be the photometry of solar flares. Accurate light-curves for these events are required so that we may be in a position to compare them with the development of: (1) the sudden disturbances in the terrestrial ionosphere, for example, geomagnetic crochets, radio fade-outs and sudden enhancements of atmospherics, which occur almost simultaneously; and (2) the 'outbursts' of radio emission which are generated in the flare regions. In Fig. 3 are plotted photometric light-curves for three distinct regions in a Class 3 flare which was recorded with the heliograph on April 7 (see also Fig. 2). One can observe here how the regions A and C, which were separated by 98,000 km. in the chromosphere, brightened up and reached their maximum intensity simultaneously. The development of the sudden ionospheric disturbance (recorded as a sudden enhancement of atmospherics on frequency 24 kc./s.) is shown in the same diagram. The time-lag of 12 min. between the peak intensity of the flare and that of the sudden ionospheric disturbance confirms the similar results previously obtained from visual records of flare line-widths made with the spectrohelioscope[3].

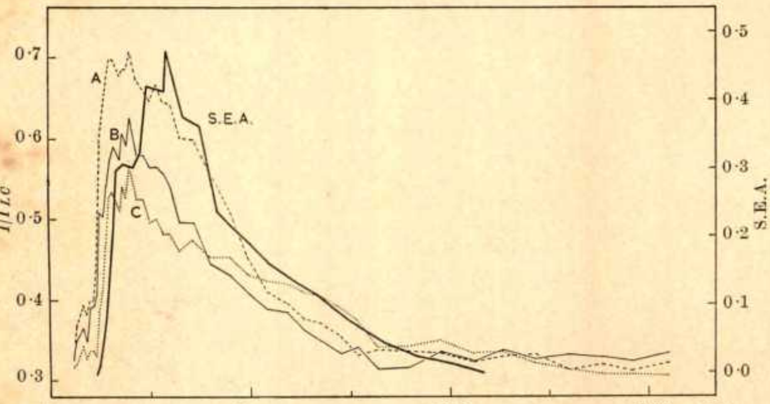

Fig. 3. Photometric light-curves plotted for three regions in the Class 3 flare of Fig. 2. Intensities are expressed in terms of the local continuum outside the wings of the $H\alpha$ line. The heavy line shows the development curve of the sudden ionospheric disturbance (recorded at Edinburgh as a sudden enhancement of atmospherics on a frequency of 24 kc./s.)

Lastly, in Fig. 4 we can see the great potentialities of the instrument as a means for providing a rapid sequence of pictures of prominence material blowing off into space at the Sun's limb. The top of this prominence arch rose through 180,000 km. in 19 min.; before it faded away, it was moving with a velocity of 625 km./sec. across the line of sight. Had the blow-off occurred near the centre of the disk, instead of at the limb, the sightline component of velocity would have shifted the prominence $H\alpha$ line some 14 A. to the violet, right outside the pass-band of the filter. The mechanism which leads to this sudden outward acceleration of solar material remains unsolved.

Three similar Lyot heliographs have been completed and delivered by the Société d'Études et de Construction d'Appareillages Scientifiques et Industriels. One has gone to Tokyo, another to Washington and the third to the McMath-Hulbert Observatory, Michigan. In the coming years we may therefore anticipate much fuller records leading to a more complete understanding of chromospheric activity; a happy situation that has been brought about largely through the inspiration and the funds of the International Geophysical Year.

[1] Öhman, Y., *Ann. Int. Geophys. Year*, **5**, Part 4 (1958).

[2] Dollfus, A., *Rev. d'Optique*, **35**, 539 (1956).

[3] Ellison, M. A., *J. Atm. and Terr. Phys.*, **4**, 226 (1953).

LONG-RANGE TRAVEL OF THE RADIOACTIVE CLOUD FROM THE ACCIDENT AT WINDSCALE

By N. G. STEWART and R. N. CROOKS
Atomic Energy Research Establishment, Harwell

LOCAL air measurements made during the course of the accident on October 10, 1957, at Windscale No. 1 Atomic Pile showed that radioactivity was released into the atmosphere between noon on October 10 and noon on October 11 (ref. 1). Meteorological conditions throughout this period were complex. During October 10 a ridge of high pressure extended over England from the east, giving mainly light south to south-west winds. A shallow depression passed close to Windscale during the evening of that day, causing the local winds to back to an easterly direction and become very light for a few hours, after which the wind returned to its original south-westerly direction. During the day, the air in the lowest 400 ft. of the atmosphere was unstable, with an inversion above. By late evening, the air near the ground was stable.

Early on October 11, at about 0100*Z*–0200*Z*, a cold front, which during the previous day had been moving south-eastwards across Scotland, passed over Windscale. At the passage of the front the wind quickly veered to the northerly and increased to about 10 knots and slowly backed to north-west during the next twelve hours. The front reached London about 1330*Z* and cleared Britain by about 1900*Z* on October 11. Behind the front, the air was unstable up to about 4,000 ft., but by the evening of October 11 the lowest layers of the atmosphere had again become stable.

Cloud Sampling

As the radioactive cloud passed over the United Kingdom and Europe, samples of the airborne dust were collected on filter papers which had been exposed in many places for monitoring industrial smoke or the dust from nuclear test explosions. Most of these filters had been exposed for 24-hr. periods, but at a number of sites continuously moving strip filters had been used, and these provided a detailed picture of the passage of the cloud overhead.

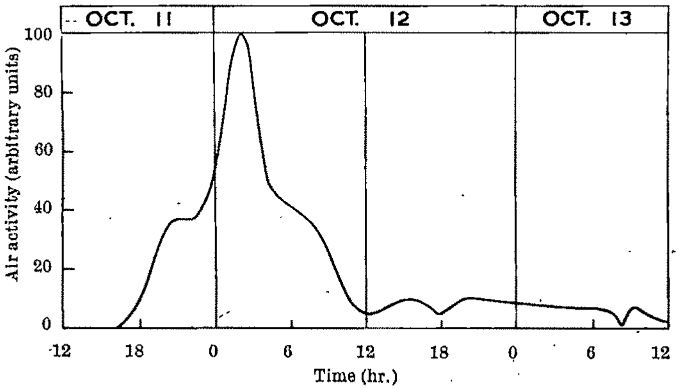

Fig. 1. Time variation of air activity at Harrow, Middlesex

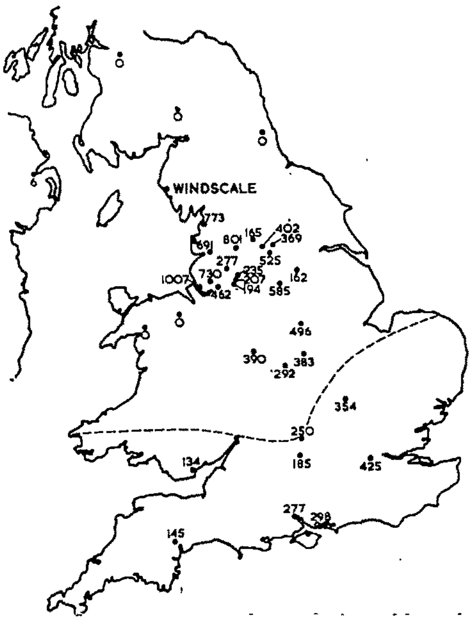

Fig. 2. Dosage of iodine-131 in air ($\mu\mu c$-days/m.^{3})

The majority of the samples from Great Britain were obtained from the public health departments of local authorities and from the Fuel Research Establishment by Mr. G. B. Courtier, of the Scientific Branch of the London County Council, who sent them to Harwell for detailed analysis. Many of the samples from Europe were obtained through the chairman of the International Geophysical Year Advisory Committee on Nuclear Radiation, Prof. W. Bleeker, who arranged for the filters exposed at routine sampling stations to be forwarded to Harwell for the measurements to be made on a common apparatus.

The results show that the cloud travelled ultimately in a south-easterly direction and had substantially passed over Lancaster by noon on October 11. It is possible to deduce from the 24-hr. samples in the Leeds–Bradford area that the cloud first reached there at about 0900*Z* on October 11 at the same time as the cold front, suggesting that this part of the cloud had initially travelled in a north-easterly direction on October 10 and had been afterwards swept southwards with the wind accompanying the front. The arrival of the cloud at Harrow, Middlesex, at 1600*Z* on October 11—some three hours after the cold front—is demonstrated in Fig. 1, which is taken from a record obtained by Dr. Herz, of Kodak, Ltd., using a moving-strip filter apparatus. The main part of the cloud passed over in about 20 hr., but low levels of activity persisted for

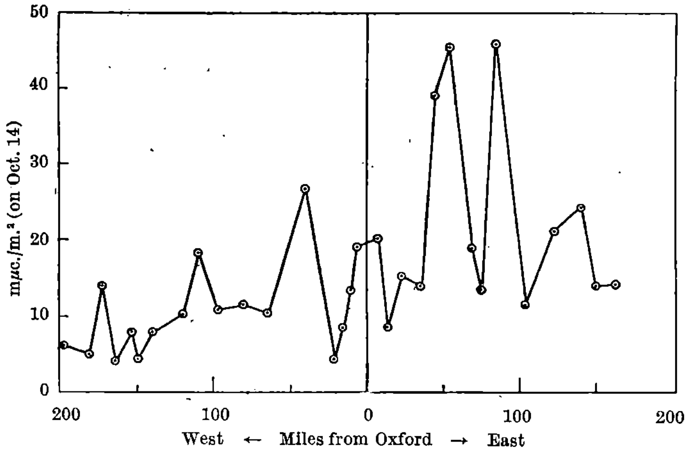

Fig. 3. Survey of iodine-131 on grass

another three days. The cloud first reached Mol (Belgium) at 1900*Z* on October 11, Frankfurt at 2200*Z* on October 12 and Sola (Norway) at some time on October 15.

Analysis of Radioactivity

The nature of the radioactivity was analysed radiochemically and by gamma-ray spectrometry, and the relative amounts of the main components on a filter exposed at Harwell (360 km. from Windscale) throughout the time of passage of the cloud are given in Table 1.

Table 1

Isotope	Half-life	Relative activity at 0001 hr. on October 11
Iodine-131	8 d.	100
Tellurium-132	77 hr.	85
Iodine-132	2·3 hr.	85
Cæsium-137	30 y.	11
Ruthenium-103	40 d.	7
Polonium-210	135 d.	2·6
Strontium-89	54 d.	0·8
Strontium-90	28 y.	0·04

The figures differ in some respects from those quoted by Chamberlain and Dunster[2] for a short-period air sample at Calder. In particular, the ratio of iodine-131 to cæsium-137 on the Calder filter was 38·5 as compared with 9·1 at Harwell. The mean value at ten sites in Great Britain south of Lancaster was 9·0 ± 1·8 (standard deviation).

The concentration of iodine-131 in the air at each sampling point has been integrated over the time of passage of the cloud to give cloud dosage figures expressed in μμc.-days/m.³. These have been plotted for the United Kingdom in Fig. 2, which shows that the cloud avoided north Wales but diffused to cover a wide front in the southern part of the country. The degree of dispersion is better shown in Fig. 3, which presents the results of a survey of the iodine-131 deposited on grass between St. David's and Cromer (dotted line in Fig. 2). It is clear that the dust cloud spread out into the North Sea and it was probably this part of it which reached Mol in Belgium some three hours after the first radioactivity reached London. The iodine-131 cloud-dosage figures observed in Europe are, as expected, smaller than those found in southern England, and some representative values are given in Table 2.

Table 2

Place	Iodine-131 dosage (μμc.-days/m.³)
Paris	2·7
Brussels	49
Eindhoven	31
Hanover	8·8
Potsdam	2·7
Vienna	1·0
Zug (Switzerland)	0·2
Hradec Kralove (Czechoslovakia)	small
Sola (Norway)	1·9

The significance of the iodine-131 cloud dosages may be judged from the fact that at the highest recorded dosage-level in Fig. 2, a child would have inhaled about 0·01 μc. of iodine-131; this is about 1 per cent of the amount it would have ingested by drinking milk at the control-level defined by the Atomic Energy Authority and afterwards ratified by the Medical Research Council[1].

Deposition of Radioactive Material

Little rain fell while the cloud passed over England, and the radioactive dust was deposited on grass mainly by turbulent diffusion and impaction. The relation between the concentration of any isotope in air and the amount deposited can be expressed in terms of a 'deposition velocity' defined by:

$$V_g = \frac{\text{amount of isotope deposited per unit area}}{\text{time integral of air concentration } (= \text{dosage})}$$

Values of V_g were determined at places where air and grass measurements were made reasonably close together. The mean value for iodine-131 obtained near Preston, Burnley and Sheffield was $V_g = 0{\cdot}30$ cm./sec., while that in southern England was 0·11 cm./sec. These values are lower than the experimental figure of 2·5 cm./sec. obtained experimentally by Chamberlain and Chadwick[2,3] at Harwell under adiabatic conditions but are qualitatively consistent with the stable air conditions which obtained during the passage of the cloud. The velocities of deposition of cæsium-137 and ruthenium-103 were less than 15 per cent of that of iodine-131; a similar difference between iodine-131 and other fission products has previously been observed by Megaw and Chadwick[4]. This preferential removal of iodine-131 from the cloud would be expected to affect the isotopic composition of the residual dust, and it is significant that the ratio of iodine-131 to cæsium-137, corrected for radioactive decay, decreased from its mean value of 9·0 in England to 5·2 in Germany and to 2·8 in Norway, where the cloud did not arrive until October 15.

We wish to acknowledge the co-operation of the many people in various European countries who collaborated in this investigation. We would also like to thank our colleagues at Harwell who analysed the samples, especially Miss E. M. R. Fisher and Mr. D. L. O. Humphreys.

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[1] Accident at Windscale No. 1 Pile on 10th October, 1957.. Cmnd. 302. (H.M.S.O., 1958.)

[2] See succeeding article.

[3] Chamberlain, A. C., and Chadwick, R. C., *Nucleonics*, 11, 8 (1953).

[4] Megaw, W. J., and Chadwick, R. C., *A.E.R.E., HP/M* 114 (1956).

DEPOSITION OF RADIOACTIVITY IN NORTH-WEST ENGLAND FROM THE ACCIDENT AT WINDSCALE

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AND

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Emission of Activity

THE course of events during the accident to No. 1 pile at Windscale on October 10 and 11, 1957, has been described in the report of the Committee of Investigation under Sir William Penney[1].

On the afternoon and evening of October 10 there was calm weather with light variable wind. A cold front was approaching from the north-west. In advance of the front there was a south-westerly wind which had an estimated speed of 7 knots at 500 ft. This wind blew for about three hours only, and with the passage of the front at Windscale about 0100 hr. on October 11, it was succeeded by a stronger northerly wind backing north-west, which blew for the remainder of that day.

The pattern of fall-out along the Cumberland coast shows that most of the deposition occurred after the north-west wind became established. Since the emission was from a 400-ft. stack, and in the presence of hot gases, the degree of turbulence at different times, as well as the wind direction, was important in determining the areas of deposition of activity.

The materials readily available for determining the nature and pattern of the deposition of activity were filter papers through which air had been passed for monitoring purposes during the incident, and grass which had received fall-out activity. Areas of one or two square yards were closely cut from areas such as roadside verges not subject to grazing by cattle. The method of measurement mostly used was gamma spectrometry. The samples were weighed and mixed, and aliquots of about 100 gm. wet-weight placed in polyethylene bottles on the crystal of the spectrometer under reproducible geometrical conditions. It was thought undesirable to dry the grass before estimating the iodine activity, lest some be lost by volatilization, although in fact no such loss was observed when samples were left exposed to the air. The dried weight of some samples was estimated by drying other aliquots. Calibration for the various nuclides was achieved by adding known amounts of activity to similar materials, and counting them under the same geometry. To enable the amounts of nuclides other than iodine to be measured, the analysis of many samples was repeated during December, by which time the iodine-131 had decayed. Details are given elsewhere[2].

Of the minority of fission products which do not emit gamma-rays, strontium-89 and strontium-90 were of obvious importance, and radiochemical analyses for these isotopes were performed.

In the first column of Table 1 are shown the activities of various nuclides, relative to iodine-131, on an air filter operated from 1000 hr. to 1030 hr. on October 11, at Calder Works, 800 metres south-east of Windscale Pile No. 1. Five cubic metres of air were drawn through the filter, and the iodine-131 activity on it was 5 μc. Also in Table 1 are shown the relative activities corrected to October 11, on samples of grass taken on October 13 at Seascale and Drigg, 3·2 and 6·4 km., respectively, south-east of Windscale. The iodine-131 activity of the Seascale sample extrapolated to October 11 was 0·16 μc./gm. dry-weight, and that of the Drigg sample 0·04 μc./gm. dry-weight. These results are similar to those of Kimber and Booth[3], who found 0·08 μc./gm. dry-weight in grass from a point 4·8 kilometres south of Windscale.

Table 1. ACTIVITY RELATIVE TO IODINE-131 OF FILTER PAPER AND GRASS SAMPLES

Nuclide	Air filter (Calder)	Grass	
		(Seascale)	(Drigg)
Iodine-131	100	100	100
Cæsium-137	2·6	1·2	2·0
Strontium-89	1·0	0·2	0·2
Strontium-90	0·02	0·004	0·01
Barium-140	2·5	—	0·5
Ruthenium-103	3·8	1·5	1·7
Zirconium-95	0·3	0·2	0·3

Small traces of other isotopes such as cerium-141, cerium-144 and ruthenium-106 were also detected.

The nuclides listed in Table 1 do not include those of short half-life; for example, tellurium-132 and its daughter product iodine-132. The presence of short-lived activities contributed appreciably to the gamma dose-rate immediately after the incident, but they were not important from the biological point of view.

Not all the fission products present in the grass were due to the Windscale incident, since all samples contain activity due to fall-out from distant bomb tests. Foliar contamination from this cause is thought to account for a considerable fraction of the activity of the non-volatile fission products such as zirconium-95 found in the grass.

The degree to which the more volatile fission products were enhanced in the activity emitted is illustrated by the ratio of iodine-131 to strontium-89. In long-irradiated fuel these nuclides are in the ratio 100 : 160, so that Table 1 shows that the escape of strontium-89 was less than 1 per cent of that of iodine-131, relative to the amounts in the pile.

Radioautographic examination of filter paper and other surfaces exposed to fall-out showed that most of the radioiodine was in gaseous form or absorbed on very small particles. Negligible amounts of uranium were disseminated in the accident, but some particles believed to be graphite with absorbed fission products were found both on air-filter papers and on the ground close to the pile. An extreme example was a 15-micron particle containing 0·8 μc. of barium-140, 0·4 μc. of strontium-89 and 0·01 μc. of strontium-90, with their daughter products, but no other detectable fission product activity. There

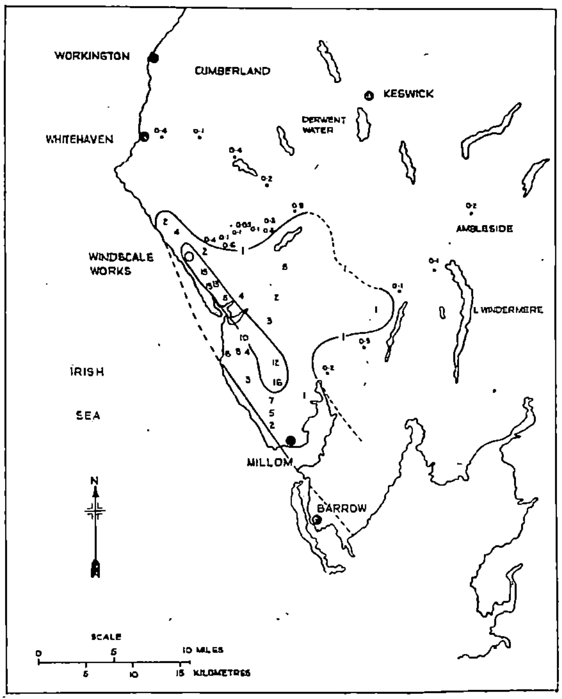

Fig. 1. Contours and spot-levels of iodine-131 activity on grass in μc./m.^{2} on October 11, 1957

evidently had been a physical separation of the elements barium and strontium, the boiling points of which are 1,140° and 1,150° C., respectively, from other fission products.

Other particles were found with activity due largely to cæsium-137. The activity associated with particles distinguishable by autoradiography or by the survey of surfaces with beta counters was, however, small in comparison with the total activity on the surface, and this was still true when measurements were repeated after the iodine-131 activity had decayed.

Deposition of Iodine-131

The fall-out pattern in Cumberland is shown in Fig. 1. The iodine-131 activity of grass has been worked back to October 11 by using the results at a location where repeated samples were taken. These showed that the activity in cut samples expressed in microcuries per square metre (μc./m.^{2}) decayed with an effective half-life of 5 days due to the combination of radioactive decay and other factors. Many more results are available than can be inserted in the figure[2].

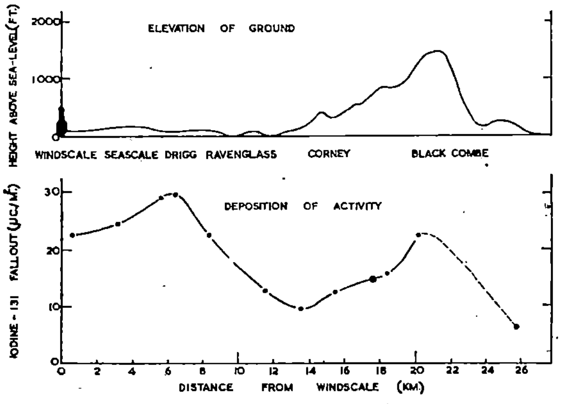

Fig. 2. Deposition of iodine-131 as a function of distance and elevation along line bearing 145° from Windscale

There is a narrow strip along the coast in which the contamination of the grass initially exceeded 10 μc./m.^{2}, but the 1 μc./m.^{2} contour extends to the Westmorland border and into the Barrow peninsula.

Theoretical relationships have been established between the amount of iodine-131 deposited and the dose-rate from the gamma-rays which are emitted[5]. Using these relations, measurements of gamma dose-rate have been used to derive estimates of the iodine-131 activity per unit area of ground, with results that agree quite well with the direct measurement of the activity of the grass. For example, at Seascale the iodine-131 activity in grass on October 11, from the sample of Table 1, was 15 μc./m.^{2}, whereas the activity deduced from the gamma dose-rate at a nearby point was 17 μc./m.^{2}.

The deposition of iodine-131 along the axis of the fall-out plume south-east from Windscale, estimated in this way, is shown in Fig. 2. There is a maximum of fall-out at Drigg, 6 km. from Windscale, and another on the slopes of the mountain Black Combe, 18 km. away. The second maximum was probably due to the elevation of the ground and the associated turbulence in the air over it, which would increase the transfer of activity to ground level.

Biological Implications

The results reported here were obtained with the aim of evaluating the physical processes affecting the released radioactivity. The greater part of the survey work following the accident was, however, concerned with assessing the magnitude and extent of the danger to man. This work was concentrated on human foodstuffs such as milk, eggs, meat, drinking water and vegetables; and it confirmed the conclusions reached from previous experimental work and theoretical assessments that iodine and strontium isotopes in milk would be the limiting contaminants. In fact, the preferential release of iodine relative to strontium made iodine the only material of biological significance.

An empirical correlation of the activities of milk and grass showed that about 10 μc./m.^{2} of iodine-131 on grass was required to give 1 μc./litre of milk. In order to protect children, milk supplies were condemned for human consumption in an area where any of the samples showed contamination of 0·1 μc./litre or more. The limit of this area followed roughly the 1 μc./m.^{2} contour of Fig. 1. It was not found necessary to impose any restriction on other foodstuffs.

A more detailed report of the surveys of milk and other foodstuffs will be published separately[4].

The collection and analysis of samples was done by many members of the staff of the Atomic Energy Authority both at Windscale and Harwell. We are especially grateful to H. Howells, W. L. Templeton, F. J. Woodman and A. E. Ross at Windscale, and to D. V. Booker, F. J. Bryant, W. H. Hardwick and M. J. Heard at Harwell.

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[1] Accident at Windscale No. 1 Pile on 10th October, 1957. Cmnd. 302. (H.M.S.O., 1957.)

[2] Booker, D. V., *A.E.R.E. HP/R* 2607 (1958).

[3] Kimber, G., and Booth, A., *Nature*, **181**, 1392 (1958).

[4] Dunster, H. J., Howells, H., and Templeton, W. L., paper to Geneva Conference, *A/CONF.* 15/P/316 (to be published, 1958).

[5] Chamberlain, A. C., *A.E.R.E. HP/R* 2606 (1958).

THE BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

New President

SIR JAMES GRAY, professor of zoology in the University of Cambridge, has been elected president for 1959 of the British Association for the Advancement of Science in succession to Sir Alexander Fleck.

Sir James has had great influence on the course that zoology has taken in Great Britain. All who were concerned with the development of the experimental approach to the study of animals which occurred in the years following the First World War would regard James Gray as the leader, and his books on ciliary action and on experimental cytology as milestones along a broadening road of achievement. The interest in movement revealed in the former led to enrichment of knowledge in a series of admirably planned and beautifully executed researches on locomotion in segmented worms, in fish and in higher vertebrates.

Early in his history he assumed the editorship of *The Journal of Experimental Biology*, which he held for thirty years, establishing it as a major scientific journal and coming in this capacity to guide the work of a whole generation of younger workers. His achievements at Cambridge are there for all to see, not least in the high distinction of his colleagues in the Department. The Marine Biological Laboratory, Plymouth, owes much to him, from the stimulus of his presence as a young research worker to the culmination of influence as president of the Marine Biological Association. He is a trustee of the British Museum, has served on the Agricultural Research Council and on many other bodies, but with little doubt would put first among these his continuing responsibilities as a Development Commissioner and as the chairman of its Fishery Advisory Committee. Few with his distinction in the field of fundamental research have encountered more widely the implications of science on human welfare.

New Officers

Lord Rennell of Rodd succeeds Mr. Maurice G. Bennett as general treasurer of the British Association. Lord Rennell's scientific interests are mainly geographical and in 1922 and 1927 he carried out explorations in the Sahara. He was president of the Royal Geographical Society in the immediate post-war period 1945–48 and did much to revive and expand the activities of the Society. He has been largely responsible for organizing the appeal for additional funds on behalf of the British Association, and the measure of his success is obvious in the number of new fields in which the Association is now operating.

Dr. Norman Wright has been elected biological general secretary of the Association in succession to Dr. George Taylor. Dr. Wright is chief scientific adviser (food) to the Ministry of Agriculture, Fisheries and Food, and he is distinguished for his contributions to research in animal ecology and the application of nutritional science to human welfare. He was the first director of the Hannah Dairy Research Institute, Ayr, where he was charged with determining the design and layout of the new buildings and initiating the research programme. He is a member of a number of important committees concerned with food and agricultural matters and has served on the Agricultural Research Council. He has travelled widely on advisory missions. At the invitation of the Governments, he has reviewed the cattle and dairy resources of India, Pakistan and Ceylon, and also the animal industry in the Middle East. He is chairman of the Programme Committee of the Food and Agriculture Organization in Rome and in 1952 he was president of Section *M* (Agriculture) of the British Association.

Soddy Commemoration Plaque

The Soddy Commemoration Plaque in the Chemistry Department of the University of Glasgow was unveiled on August 27. Sir Hector Hetherington, vice-chancellor and principal of the University, presided at this occasion. He welcomed some relatives of Prof. Soddy who were in attendance and Prof. H. J. Emeléus, who represented the Royal Society. He then read a complimentary telegram from the Nobel Foundation, Stockholm. Sir Alexander Fleck, with a wise, reminiscent and affectionate speech, unveiled the bronze plaque with its portrait in relief and the citation "With Rutherford he shared the discovery of atomic disintegration, with Ramsay the proof of helium production from α-particles. In this Department he formulated his conception of isotopes". Prof. J. Monteath Robertson, in accepting the memorial tablet, thanked Mr. James Barr, the artist, and also Dr. Andrew Kent, who had organized the proceedings and also a Soddy exhibition including the original piece of isotopic lead—208—which had been loaned by Prof. McNeill of Toronto.

FREDERICK SODDY, M.A., LL.D., F.R.S.

A photograph (R. Cowper) of the plaster-cast by James Barr, D.A., for the memorial plaque in the Chemistry Department, University of Glasgow. It is based on photographs of or about his Glasgow period (1904–14) and on the Cannizzaro medal by "T.S.S.".

Endeavour Prizes

The prizes awarded for the 1958 *Endeavour* Essay Competition were presented by Sir Alexander Fleck on August 29, during the reception for exhibitioners in the Randolph Hall of the University of Glasgow. The competition is sponsored annually by Imperial Chemical Industries Limited, publishers of the quarterly scientific review *Endeavour*, and is limited to those under twenty-five years of age. Ninety-two entries were received, but, although many were from abroad, all the prize-winners this year come from the British Isles. The first prize of 50 guineas was awarded to Mr. Charles Perrin, of Winchester College, for an essay on "Darwinism Today". The second prize of 25 guineas was awarded to Miss Angela Glynn for an essay on "Education for an Age of Science". Miss Glynn is a student at Newnham College, Cambridge. The third prize of 15 guineas was awarded to Mr. John Christopher Horrocks, of Halifax, Yorkshire, for an essay on "Rockets and Satellites and their Scientific Significance". Mr. Horrocks is studying for an external London degree at Bradford Institute of Technology. Two special prizes of 5 guineas were awarded to competitors under eighteen. Mr. Anthony Orchard, of Swansea, received one of these for an essay on "Chemicals from Petroleum". He is at present at the Bishop Gore Grammar School for Boys. The second was won by Mr. Andrew Billson, of Nottingham, for an essay on the same subject. Mr. Billson is at the Becket School, West Bridgford.

NEWS and VIEWS

Physics at the University College of Wales, Aberystwyth : Prof. W. J. G. Beynon

Dr. W. J. G. Beynon, at present a senior lecturer in the University College of Swansea, has been appointed to the chair of physics at the University College of Wales, Aberystwyth, in succession to the late Prof. R. M. Davies (see *Nature*, 181, 879 ; 1958). Dr. Beynon graduated in the University of Wales (University College of Swansea) in 1934, with first-class honours in physics, and then proceeded to research in the Department of Physics at Swansea, obtaining his Ph.D. degree for work on magneto-optical dispersion in 1939. During 1938–46 he worked in the Radio Division of the National Physical Laboratory on ionospheric problems in radio communication. In 1946 he returned to the Department of Physics at Swansea as lecturer, being promoted to senior lecturer in 1949. With research students, he continued work on ionospheric problems, and in 1951 was awarded the degree of D.Sc. (Wales). His published work is concerned with radio-wave propagation, reflexion and absorption in the ionosphere, and in some papers he collaborated with Sir Edward Appleton. Recent publications have been on solar eclipses and radio studies during the International Geophysical Year, for which he is a 'world correspondent' on the ionosphere. He has been general editor of the Proceedings of the International Joint Commission on the Ionosphere, and has served on many committees, national and international, including those dealing with artificial Earth satellites, and rocket investigation of the upper atmosphere. He was a member of the official British delegation to General Assemblies of the Scientific Radio Union at Zurich (1950), Sydney (1952), The Hague (1954), and Boulder (1957), and has recently visited Moscow.

Report on Education

The report of the Ministry of Education, "Education in 1957" (pp. v+198. (Cmnd. 454). London: H.M. Stationery Office, 1958. 9*s*. net), brings together a good deal of information which has been given piecemeal to Parliament, and presents a convenient picture of trends, some of which, notably in further education, are of particular interest to the scientist. During 1956 the number of senior children in all-age schools was reduced by 10 per cent, while during 1957 completion of new buildings permitted the re-organization of 203 all-age schools, and there are 260 projects in the approved building programme, completion of which will enable 1,300 more all-age schools to be re-organized. New building work to the value of more than £60 million has now been authorized for the first four years of the five-year plan for the expansion of technical education, out of a total of £70 million, and by the end of 1957 work had begun on twenty new colleges and 102 major extensions to existing colleges. Although the staffing position in the primary schools improved slightly, it continued to deteriorate in the secondary schools, and the report emphasizes the need for a considerably larger number of teachers of mathematics and science when the number of children in the secondary schools rises in the next few years. Statistics and a graph included in the report point to a new peak expected in the school population in 1968 almost as high as that expected in 1961. The number of full-time teachers in technical colleges rose from 10,817 to 12,139, and of part-time teachers from 47,024 to 49,320, but the increase is still short of that considered necessary by the Willis Jackson Committee. The year was notable for the number of visitors to the Science Museum, the figure of 1,317,000 having only been exceeded in 1935 (1,327,000).

Russian Scientific Journals available in English

The U.S. National Science Foundation has published a useful list of Soviet scientific and technical journals now available in English translation. 60,000 pages a year are now in print and these include 53 English editions of Russian journals, four extensive series of translated Russian abstracts of scientific papers, and four series of partial translations of important Russian journals. The list includes subscription rates and details of where the translations can be ordered. It can be obtained from the National Science Foundation, Washington 25, D.C.

The Australian Museum, Sydney

So long ago as 1827 Earl Bathurst suggested that a public museum be established in New South Wales, where "many rare and curious specimens of natural history are to be procured". By 1852 the first portion of the permanent building had been erected. The whole building will be completed by the construction of the North Wing, which is due to begin very soon. From its early days, the Museum has been distinguished for arranging its exhibits in attractive form and for publications designed to appeal to all with an interest in natural history. The latest publication, "Handbook to the Australian Museum", replaces the former "Guide" and has been designed to help make visits to the Museum of increased interest by providing information not only about the exhibits themselves but also of the theme that links them all together. Approximately 250,000 people visit the Museum each year.

The report of the Trustees of the Australian Museum for the year ended June 30, 1957 (pp. 23. Sydney: The Australian Museum, 1958), includes a valuable summary of the growth and development of this progressive institution. The main purpose of this statement is to indicate that for a period of no less than forty-seven years no major building developments have taken place, and this in spite of many applications to the authorities for increased accommodation. Plans and designs for new displays have been prepared for the aboriginal, bird, fish, invertebrate, insect, mineral, mammal and fossil galleries. Special quarterly exhibits help to produce a lively atmosphere, and popular lectures on scientific subjects connected with the museum objects are well attended.

Library Resources in the West Midlands

The West Midlands Group of the Reference and Special Libraries Section of the Library Association has compiled a "Guide to Library Resources in the West Midlands" (pp. viii+49. London: Library Association, 1958. 15*s*.). Edited by B. G. Staples, it indicates the character, coverage and availability of 178 libraries in Herefordshire, Shropshire, Staffordshire, Warwickshire and Worcestershire. The staff, book-stock and number of periodicals, but not the titles, are given and only to a limited extent does it supply a picture of the resources of the region. There are two indexes: one, topographical, showing the different types of library in each locality; while the general index gives a key to particular subject fields and named collections, as well as indicating where microcard and microfilm readers and certain classes of material can be found. This well-produced pamphlet bears further witness to the preparatory work which this and similar groups are carrying out in different parts of Britain and on which an adequate regional library system may perhaps ultimately be based.

Health Physics

A new journal is a mixed blessing. The hopeful scribe sees in it another vehicle for his works, while the harassed executive sighs at the thought of more to read. Nevertheless, no one can grudge a new discipline its own organ. Health physics is such a new discipline; a Health Physics Society has recently been formed in the United States and has now published the first issue of its journal, *Health Physics* (1, No. 1, June 1958. Pp. 95. Subscription: 17 dollars; 120*s*. per annum. New York and London: Pergamon Press, 1958). In the foreword by K. Z. Morgan (editor-in-chief) health physics is defined "as a study and practice dealing with any and all factors relating to damage from ionizing radiation and the prevention of such damage". With the rapid promotion of nuclear energy and the increasing utilization of its by-products, there can be no doubt that the fantastic growth of this new corps of specialists from a handful of dedicated enthusiasts to a substantial army will be continued. They will welcome this journal devoted to "(1) Research, (2) Engineering, (3) Applied, and (4) General"—which is a fairly broad programme—and the first number, of June, has plenty of category (4).

"Atom 1959"

Under the title "Atom 1958" (pp. 24. London: H.M. Stationery Office, 1958), the Atomic Energy Authority has issued for general reading a summary, with illustrations, of the Authority's fourth annual report (see also p. 615 of this issue of *Nature*). The pamphlet describes in non-technical terms the progress of the power programme, the possibilities for the next two decades, including the prospects for a fusion reactor, and the relations of the Authority with industry and with other countries. Besides some notes on health and safety and the supply of fuel for reactors, it includes an outline of the Authority's organization and lists of its establishments and publications. It is a well-planned contribution to public relations which should help to remove some popular misunderstandings and dispel the dangerous sense of mystery with which those relations are sometimes cloaked.

Czechoslovak–Hungarian Polarographic Conference

The Czechoslovak–Hungarian Polarographic Conference in Prague was held during July 13–24 following the similar meeting held in 1955 at the Hungarian Chemical University in Veszprém. The Conference was arranged by the Polarographic Institute of the Czechoslovak Academy of Sciences under the auspices of its Chemical Section. Prof. J. Heyrovský presided. The Hungarian delegation consisted of nineteen scientists and was led by Prof. J. Proszt (Budapest Technical University), Prof. K. Polinszky (dean, Veszprém Chemical University) and Dr. V. Cieleszky (chairman, Polarographic Section, Hungarian Chemical Society). Besides these, there were thirty-five visitors from Budapest and several polarographic experts from other countries, including Prof. G. Semerano (Padua); Dr. Z. Zagórski (Poznań); W. Stolle (German Academy, Berlin), who brought a gift of a newly constructed pen-recording polarograph; L. Lukashev (Bulgaria); Prof. B. P. Bruns (Moscow); and Dr. R. J. Magee (The Queen's University, Belfast). Sixty-three papers were presented at the Conference in two sections: *A*, inorganic–analytical; and *B*, organic and biochemical. After the meetings in Prague the delegates went to Bratislava and were shown around research establishments and chemical works in Czechoslovakia, as well as the Tatra Mountains. The majority of the papers were of high standard and some indicated new directions in polarography. They will be published chiefly in "Collection of Czechoslovak Chemical Communications". Those who are interested in the abstracts of the Communications should apply to Prof. J. Heyrovský, Polarographic Institute of the Czechoslovak Academy of Sciences, Vlašská 9, Prague 1, Czechoslovakia.

A Submarine Volcano

As reported by Y. Y. Gakkel (*Priroda*, 4, 87; 1958), the members of the polar drifting station in November 1955 discovered a submarine volcano situated at 88° 16′ N., 65° 36′ W. on the Lomonosov submarine ridge near the North Pole. The nature of the ice-quakes, noises and hydrogen sulphide emerging from a crack in the ice—all these phenomena have suggested the presence of a submarine volcano in eruption. The author of this article postulates a tectonic fracture stretching along an arc from the Ellersmere Land to the Taimyr peninsula. Along this line the following newly discovered features can be located: the problematic volcano, dredged volcanic glass and basaltic hornblende, the latter being also found in other localities of the Arctic Ocean.

Seed Transmission of Plant Virus Diseases

OF the considerable number of known plant virus diseases, only some forty-five are reported to be seed-transmitted, and of these only a few cases of actual embryo infection are known. N. C. Crowley, who has already demonstrated the presence of virus inhibitors in the seeds of several species, but not of virus inactivators, has now made further contributions on this topic (*Austral. J. Biol. Sci.*, 10, 443 and 449; 1957). He has shown, by growing tomato embryos in media containing the virus, that there is no evidence for the presence of virus-inactivating substances in the embryos. Evidence is presented that whereas some of the highly infectious viruses commonly infect the seed testa, and even the endosperm, the developing embryo usually, and typically, remains uninfected. Since it has not been possible to obtain evidence of the presence of virus-inactivating agents in either the endosperm or the embryo, the favoured hypothesis to account for the rarity of seed-transmission is that the absence of plasmodesmatal connexions between the embryo and its tissue environment prevents its becoming infected. In a series of critical experiments, using well-known viruses and hosts, Crowley has shown to what extent the testa, the endosperm and the embryo may become infected in different cases. Again, all the evidence obtained indicates that the absence of seed-transmission of highly infectious viruses cannot be explained except in terms of the plasmodesmatal hypothesis. The alternative hypotheses (1) that the viruses induce sterility, (2) that the hosts contain inactivating substances, and (3) that developing embryos inactivate virus particles in the surrounding medium, are not validated by any evidence so far obtained. In the case of those virus diseases, for example, bean mosaic virus, that are seed-transmitted, this appears to depend on the ability of the virus to infect the microspores, macrospores or embryo sac before fertilization; but embryos themselves seem to be singularly free from infection. As the author points out, since natural selection would tend to eliminate any line of plants readily subject to the seed-transmission of a severe virus disease, the rarity of the latter phenomenon finds a simple and direct explanation.

Medical Research Council Travelling Awards

THE Medical Research Council has made the following travelling awards for the academic year 1958–59. *Rockefeller Travelling Fellowships in Medicine:* Dr. G. Burnstock, Department of Pharmacology, Oxford; Mr. P. J. Holloway, Medical Research Council Laboratories, Hampstead; Mr. W. B. Jennett, lecturer in neurosurgery, University of Manchester; Dr. A. P. Mathias, lecturer in biochemistry, University College, London; Dr. R. P. Michael, Department of Experimental Neuroendocrinology, Institute of Psychiatry, Maudsley Hospital, London; Dr. P. H. A. Sneath, National Institute for Medical Research, Mill Hill. *Lederle Travelling Fellowship in Medicine:* Dr. R. J. Linden, lecturer in physiology, University of Leeds. *Alexander Pigott Wernher Memorial Travelling Fellowship in Ophthalmology and Otology:* Dr. G. B. Arden, Institute of Ophthalmology, London. *French Exchange Scholarships in Medical Science:* Miss J. E. Cremer, Medical Research Council Toxicology Research Unit, Carshalton, Surrey; Miss S. Reiman, Institute of Psychiatry, Maudsley Hospital, London.

Travelling Fellowships in Medicine have been awarded by the Eli Lilly Company of Indianapolis, after nomination by the Medical Research Council, to the following candidates: Mr. J. D. Griffiths, St. Bartholomew's Hospital, London; Dr. C. W. M. Wilson, lecturer in pharmacology and therapeutics, University of Liverpool. Travelling Fellowships in Medical Science have also been awarded by the United States Public Health Services, National Institutes of Health, Bethesda, Maryland, after nomination by the Medical Research Council, to the following candidates: Dr. B. S. Hartley, Department of Biochemistry, University of Cambridge; Dr. K. W. Cross, St. Mary's Hospital Medical School, London; Dr. A. Doig, Royal Infirmary, Edinburgh.

Announcements

THE Ministry of Supply announces that Dr. J. S. McPetrie has been appointed director-general of Electronics Research and Development in succession to Dr. D. H. Black.

A MEETING of the Photobiology Group on "Some Aspects of the Physiology of Vision" is to be held in the University Laboratory of Physiology, Oxford, during September 26–27. Registration forms and further details can be obtained from the chairman of the Photobiology Group, Dr. M. H. Pirenne, University Laboratory of Physiology, Oxford.

THE Radio Frequency Spectroscopy Group (chairman, Prof. E. R. Andrew, Bangor) is to hold a conference on "Applications of Magnetic Resonance to Solid State Physics" at King's College, Newcastle upon Tyne (University of Durham), during September 22–23. The programme includes contributions on electron resonance of colour centres and iron group impurities in ionic crystals, nuclear resonance in ionic solids, electron spin, nuclear and cyclotron resonance in semi-conductors. Further particulars and application forms can be obtained from Dr. E. E. Schneider, King's College, Newcastle upon Tyne.

AN international conference on "Small Angle X-ray Scattering from Metals" will be held at Midwest Research Institute, Kansas City, Missouri, during September 23–25. The purpose of the meeting is to bring together active workers in the field to discuss the origin of the scattering as it relates to the crystal structure of metals. Arrangements for the conference have been made by the following committee: C. S. Barrett, Institute for Study of Metals, University of Chicago; Paul A. Beck, University of Illinois; W. W. Beeman, University of Wisconsin; and J. C. Grosskreutz (chairman), Midwest Research Institute, Kansas City, Missouri, from whom further information can be obtained. Financial support is being provided by the National Science Foundation, the Office of Ordnance Research, the Office of Naval Research, the Wright Air Development Center, U.S. Air Force, and Midwest Research Institute. The proceedings will be published as a special section of the *Journal of Applied Physics.*

THE ACCIDENT AT WINDSCALE ON OCTOBER 10, 1957

THE final report* on the accident to No. 1 pile at Windscale on October 10, 1957, should be considered in relation to the previous reports[1-3].

During a routine Wigner energy release, temperatures in the pile rose beyond safe limits, causing a fire which affected 150 channels and caused a certain amount of radioactivity, mainly iodine, to be released over an area of Cumberland. Following this incident, a committee of inquiry was set up under Sir William Penney, and reporting to the Prime Minister. A less technical version of its report has already been published[1]. In the memorandum by the Prime Minister the immediate cause of the accident was given as "the application too soon and at too rapid a rate of a second nuclear heating to release the Wigner energy from the graphite . . .". The accident was considered as being due partly to inadequacies in the instrumentation and partly to faults of judgment by the operating staff, these faults of judgment being themselves attributed to weaknesses of organization.

Three committees were set up, each under the chairmanship of Sir Alexander Fleck, to advise on certain aspects of the incident. The committees on Organization and on Health and Safety reported in December 1957[2] and January 1958[3], respectively. The report of the Technical Evaluation Committee, the subject of this article, was delayed due to the need to carry out a considerable amount of experimental and analytical work.

The Committee's terms of reference were: (1) to consider the new information available following the accident; (2) to consider the possible methods of carrying out the controlled release of Wigner energy; and (3) to advise the United Kingdom Atomic Energy Authority on the restarting of Windscale No. 2 pile.

The report begins by considering the phenomenon of energy storage in irradiated graphite—Wigner energy. This storage is due to defects in the crystal structure of the graphite following neutron bombardment. The energy is releasable, in varying extent and rate, by heating the graphite. The amount of energy stored decreases rapidly with an increase in the temperature at which irradiation takes place, that is, there is an annealing effect. This feature makes the effect particularly severe in low-temperature reactors such as BEPO and the Windscale piles, but very much less important in the Calder and subsequent power-producing reactors. The Committee states that if the release of energy in No. 2 pile was attempted as previously, graphite temperatures in excess of 400° C. would almost certainly occur in considerable masses of graphite, and that temperatures in some pockets where previous releases had not been effective might reach 500° C.

The report next considers the implications of these transient high temperatures on the graphite, the fuel and the other materials in the reactor. A temperature limit of 400° C. is considered as reasonable for the graphite. Under these conditions the fuel element design is satisfactory. Having specified temperature limitations, the real problem is that of installing sufficient and effective instrumentation. A considerable increase in the number of graphite and fuel element thermocouples is required, and the fission product detection scanning gear needs improving.

A description of four methods of carrying out Wigner releases is then given. The first method, the one previously employed, uses nuclear heating to initiate the release of energy. The main difficulty is the non-uniformity in the spread of the release, leaving pockets unannealed. The Committee deprecates the application of a second nuclear heating to initiate the release of these pockets, as being certain to lead to excessive uranium temperatures, and recommends that no further releases by this method should be attempted. The second method was used with the BEPO reactor in March this year, but is not recommended for Windscale. The third method, a slow heating method, is also discarded, since it would cause excessive stresses in the concrete reactor structure. The fourth method combines the previous two. It is proposed that a partial anneal using a slow heating method should first be carried out, followed by a more rapid heating to a somewhat higher temperature. The heat would be supplied by heating the ingoing air. The necessary plant and instrumentation could be installed in 6–9 months, making the pile operational again in about a year.

No. 1 pile has added considerably to our knowledge of reactor technology and operation. It is hoped that No. 2 pile will be recommissioned, since the development of methods for altering the pattern of the instrumentation in a reactor after it has been in service will prove most useful as the nuclear power programme develops.

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* Atomic Energy Office. Final Report of the Committee appointed by the Prime Minister to make a technical evaluation of information relating to the design and operation of the Windscale piles, and to review the factors involved in the controlled release of Wigner energy. Pp. 20. (Cmnd. 471.) (London: H.M. Stationery Office, 1958.) 1*s*. net.

[1] Accident at Windscale No. 1 pile on 10th October, 1957. (Cmnd. 302.) (H.M. Stationery Office.) *Nature*, **180**, 1043 (1957).

[2] The organization of certain parts of the U.K.A.E.A. (Cmnd. 338.) (H.M. Stationery Office.) *Nature*, **181**, 439 (1958.)

[3] The organization for control of health and safety in the U.K.A.E.A. (Cmnd. 342.) (H.M. Stationery Office.) *Nature*, **181**, 1023 (1958).

EXCHANGE OF INFORMATION ON ATOMIC ENERGY

THE Agreement between the Governments of the United Kingdom and of the United States for Co-operation on the Uses of Atomic Energy for Mutual Defence Purposes described in the White Paper* published on July 8 comprises twelve articles. The first is a general provision for the exchange of information and transfer of materials and equipment, unless such co-operation represents an unreasonable risk to the defence and security of the communicating or transferring party. Under the second article the two parties agree to communicate or exchange classified information jointly determined as necessary to the development of defence plans, the training of personnel in the use of or in defence against nuclear weapons, the development of delivery systems for such weapons, and on research, development and design of military reactors, as well as other classified information required to improve the design, development and manufacture of nuclear weapons. The transfer of submarine nuclear propulsion plant and materials is covered specifically in the fourth article, while questions of responsibility, conditions and guarantees are dealt within the next three. Article VII restricts the communication of classified information or material transferred under the Agreement to third parties without prior authorization, and under Article VIII agreed classification policies are to be maintained and the present practice of consultation continued. The longest article (IX) is that dealing with patents, and includes provision for the issue of appropriate secrecy or prohibition orders. These clauses, however, make it possible for firms in one country to enter directly into relations with firms in the other on the sale of patents and licences, and should thus ease the exchange of information between the two countries where it had been hindered because information which was the property of individual British firms would, if exchanged, become the property of their American competitors.

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* Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the United States of America for Co-operation on the Uses of Atomic Energy for Mutual Defence Purposes, Washington, July 3, 1958. Pp. 8. (Cmnd. 470.) (London: H.M. Stationery Office, 1958.) 6*d*. net.

As the Prime Minister explained in the House of Commons on July 8, the new Agreement, which supersedes that of June 1955, has been negotiated in consequence of the amendment of the United States Atomic Energy Act, 1954, so as to permit closer and more fruitful collaboration between Great Britain, the United States and other friendly countries. The Agreement was signed on July 3 but cannot become effective until it has lain before Congress for thirty sitting days, and the Prime Minister preferred not to comment at that time on the practical results which might be expected when the Agreement comes into effect. We had been in close touch with the Commonwealth countries during the negotiations leading to the Agreement and co-operation with these countries was covered by Article VII. On July 15 Mr. Macmillan added that the United States Atomic Energy Act, as amended, still did not permit the transfer of complete nuclear weapons or manufactured nuclear components of such weapons, and the Agreement accordingly dealt rather with research and development than with the actual interchange of weapons. Replying to further questions in written answers on July 17, Mr. R. A. Butler said that no commitments or understandings were entered into which might have the effect of surrendering patent rights in the Calder Hall type of reactor. British interests were satisfactorily safeguarded by the clauses of the Agreement, and the Government saw no reason to expect that the undertakings to make available to the United States Atomic Energy Commission information about the Calder Hall design and the standard fuel elements used in the Calder Hall reactors would have any substantial effect on our export prospects. In the House of Lords on July 21, the Earl of Gosford said that this information related only to the Authority's own dual-purpose reactors and did not and would not include information developed from Calder Hall and included by industry in its latest nuclear power station designs. The Agreement was concerned exclusively with co-operation in the use of nuclear energy for defence and not with arrangements for co-operation on civil uses.

COLONIAL DEVELOPMENT

THE schemes made under the Colonial Development and Welfare Acts in the period April 1, 1957–March 31, 1958, which are detailed in the latest return*, bring the total commitments, from April 1, 1946, under the Acts to £194,259,668, of which £17,203,311 is for research schemes. The totals for the year in question are £17,480,563 for development and welfare and £1,123,850 for research schemes. Of this last, £351,709 is for agriculture, £158,830 for tsetse and trypanosomiasis, £106,207 for medicine, £101,108 for insecticides, £76,859 for fisheries, £72,622 for social science, £52,240 for products research, £23,546 for locust control, and £14,340 for economic research.

Of the actual research schemes, £135,730 is supplementary provision for the East African Trypanosomiasis Research Organization, 1957–60; £70,156 for the Colonial Pesticides Research Unit, Arusha, 1957–58; £66,858 for maintenance of the Colonial Road Research Section at the Road Research Laboratory, Harmondsworth; £65,000 for expansion of vaccine production and associated research in Nigeria; £51,675 for agricultural research in Swaziland; a further £49,300 for expansion of the Tropical Products Institute; £49,064 for the East African Scientific and Industrial Research Organization, 1957–60; a supplementary £43,056 for the Colonial Microbiological Research Institute, Trinidad; £37,785 for soil and land use surveys in British Guiana; £34,185 to establish a Veterinary Investigational Laboratory in Bechuanaland; £32,992 for the Nigerian Institute of Social and Economic Research; and £30,938 for the joint capital housing programme for the East African Agricultural and Forestry Research and Veterinary Research Organizations.

Other major research schemes include £23,546 for the Desert Locust Survey; a supplementary £30,800 to establish a Soils Laboratory in Sarawak; £23,023 for the study of soil fertility maintenance in high-rainfall areas in Nigeria; a further £22,084 for the Fisheries Development and Research Station, Sierra Leone; a further £20,100 for the West African Institute for Trypanosomiasis Research; £19,370 for control of malaria in a hyperendemic area of East Africa; and a supplementary £15,833 for sugar technology research at the College of Tropical Agriculture, Trinidad.

The development and welfare schemes follow the general pattern of recent years. A further grant of £644,000 goes to the Central Organization for Overseas Geodetic and Topographical Survey; Kenya receives £507,880 for the intensification of African agricultural development, with a further £508,120 for Agricultural Department expenditure in connexion with that intensification. Farm development in Jamaica receives a further £750,880, with £177,375 for expansion of cocoa production. £156,973 goes for soil conservation in Basutoland; a further £81,394 for control of tsetse fly in the Bechuanaland Protectorate; and £234,000 for development of broadcasting services in Kenya. Among the many grants for road development may be mentioned £771,680 to the Western Region of Nigeria; £288,000 to Tanganyika (a further £280,000 for improvements to the Eastern Trunk Road); £300,000 for improvement of territorial roads in Kenya; £156,000 for survey of roads in Swaziland; £817,250 for construction of a trunk road from Scrian to Simanggang, Sarawak; and £103,692 for reconstruction of the East Coast Georgetown–Rosignol road, British Guiana. Grants of £464,295 to the Western Region, Nigeria, and £99,000 for the Scaries area, Sierra Leone, illustrate the grants for the development of water supplies. £200,000 is for the establishment of the Jamaica Institute of Technology, and among the many grants for university education can only be mentioned £198,000 for the erection of a Men's Hall of Residence at the University College of East Africa and a supplementary £154,650 for the erection of the new library; £200,000 towards a new library at the University of Hong Kong; and £156,188 for the construction of buildings for the Faculty of Medicine, University College of the West Indies. There are numerous grants for secondary and primary education, the largest being £584,000 for the expansion of general education in Lagos.

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* Colonial Development and Welfare Acts. Return of Schemes made under the Colonial Development and Welfare Acts by the Secretary of State for the Colonies, with the concurrence of the Treasury, in the period from 1st April, 1957, to 31st March, 1958. Pp. 36. (House of Commons Paper No. 223.) (London: H.M. Stationery Office, 1958.) 2*s*. net.

SAFETY IN MINES IN GREAT BRITAIN

THE Mines Inspectorate, apart from the Headquarters organization at London, is divided into eight divisions, namely, Scottish, Northumberland and Cumberland, Durham, North Eastern, North Western, East Midland, West Midland and Southern, and South Western. Each division is in the charge of a divisional inspector who is required, under the Coal Mines Act of 1911, to present an annual report to the Minister of Power. The reports* for each of the eight divisions for 1956 have been published at intervals during the first few months of 1958; these are the last reports under the 1911 Act, for the Mines and Quarries Act, 1954, became effective on January 1, 1957.

The reports follow a similar pattern, beginning with an introduction which contains short accounts of production in the divisions, reorganization of collieries, new work, introduction of new methods of working, new machines used and experimental work on techniques of mining, roof support, shot firing, ventilation and so forth. This is followed by a section devoted to administration, in which are summarized the establishment and organization of the staff, the activities of the inspectors, inspections made on behalf of workmen, and prosecutions. One of the most interesting and significant features of this section in the reports is that nearly every divisional inspector refers to a serious shortage of staff, although one or two gave their opinion that there were signs of improvement in the near future. The shortage of inspectors has meant that the amount of preventive work undertaken was much less than desirable. The effect of the shortage was aggravated by the additional work caused in preparation for the implementation of the 1954 Act at the beginning of 1957; for example, in one division alone the Divisional Committee of the Mining Qualifications Board (a committee which includes inspectors of mines) examined the qualifications of more than 2,000 mechanics and examined about 100 of these orally; and certificates were issued in that division for more than 500 deputies and for nearly 900 shot-firers.

Over Great Britain as a whole, proceedings were taken against two management officials. Managements took legal proceedings against subordinate officials and workmen in about 340 cases, more than half of which were for contraventions in connexion with contraband (matches and smoking); two-thirds of these cases occurred in one division.

The main section of each report deals with accidents and their prevention. During the year there were 300 fatal accidents at mines (compared with an average of 396 in the three preceding years), and more than 1,760 men reportably injured (about 1,900 on the average in the three preceding years). There were also 148 dangerous occurrences (gas ignitions, fires, breakages of winding gear and so forth). Accidents are investigated and analysed by the inspectors. There is, considering the country as a whole, a gradual downward trend in the number of fatalities and reportable injuries each year, and in two divisions they were the lowest ever recorded; the numbers are, as the inspectors stress, unduly high. An analysis of all the accidents in 1956 shows that, in the opinion of the examining inspectors, about 80 per cent were avoidable (the actual percentages in different divisions vary from 76·3 to 81·7) and the remaining 20 per cent "unavoidable under existing conditions".

Of the avoidable accidents, some were due to defective machinery, some to neglect or breach of rules by officials or by workmen, but most (from about a half to three-quarters of avoidable accidents in different divisions) were classified as "avoidable by ordinary caution". Over Great Britain as a whole, about 35 per cent of the accidents were due to falls of ground, about 25 per cent were on haulage and transport, about 30 per cent due to miscellaneous causes, and about 10 per cent were due to accidents on the surface.

Sections in each of the reports are devoted to safety organization, training and education, and health and welfare. A noteworthy feature is the interest taken by miners in rescue training and rescue competitions, in first-aid work and competitions and in civil defence work. The rescue organization of the coal mining industry, which depends largely upon rescue teams of volunteers trained at special rescue stations, is a fine one and, as reported by the inspectors, whose duties include inspection of the rescue stations, there is no lack of volunteers for rescue work.

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* Ministry of Power. Reports of H.M. Inspectors of Mines under the Coal Mines Act 1911, for 1956. Durham Division. By W. Brown. Pp. ii+30+8 plates. 2*s*. 6*d*. net. North Western Division. By G. Hoyle. Pp. ii+36+4 plates. 3*s*. net. North Eastern Division. By C. W. Scott. Pp. ii+38+6 plates. 2*s*. 6*d*. net. Scottish Division. By W. Widdas. Pp. ii+28+4 plates. 2*s*. 6*d*. net. East Midland Division. By W. B. Brown. Pp. ii+34+4 plates. 3*s*. net. South Western Division. By T. A. Jones. Pp. ii+24+4 plates. 2*s*. 6*d*. net. West Midland and Southern Division. By J. E. Henshaw. Pp. ii+24+2 plates. 2*s*. 6*d*. net. Northumberland and Cumberland Division. By H. Hyde. Pp. ii+30+6 plates. 2*s*. 6*d*. net. (London: H.M. Stationery Office, 1958.)

The inspectors, as their reports show, take a keen interest in training and education, and report on the training centres, training faces and courses of instruction in each division. In 1956 more than 17,000 juveniles and more than 15,000 adults received preliminary training; these figures indicate the immense task of training in the coal industry, especially as face training has to be arranged and courses for potential shot-firers and potential deputies (quite apart from courses for senior officials, which are not referred to in detail).

Sections on health and welfare refer mainly to work carried out in improving dust control, ventilation, lighting, sanitation and so forth, and to the provision of medical centres at collieries.

Each divisional report includes a section devoted to horses. Although the number of horses employed at collieries is decreasing, more than 10,000 were employed in 1956. In general, the miner is devoted to his horses and they are well cared for.

Although the general pattern of the reports is similar, they are not stereotyped. Probably few people unconnected with the mining industry will read them, but they are very well worth reading, for they are personal reports and are far from the dry-as-dust documents they might have been.

The reports for 1957 of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, have also recently been published; these are the first reports under the 1954 Act which became effective on January 1, 1957. It makes provision for all classes of mines and quarries to be dealt with together, and the Inspectors' reports include, in separate parts or sections, reports on coal mines; mines of stratified ironstone, shale and fireclay; miscellaneous mines (including metalliferous mines); and quarries*.

The general pattern is similar to the earlier divisional reports, which dealt only with coal mines and other so-called stratified mines. As may well have been expected, by far the greater part of each report deals with coal mines and the conclusions are similar to those for 1956.

Until 1957 the reports of H.M. Inspectors of Mines and Quarries on metalliferous mines and quarries were presented in a single publication for the whole country by H.M. Chief Inspector of Mines and Quarries under the Metalliferous Mines Regulation Act, 1872, and the Quarries Act, 1894; the last report under these Acts was published early in 1958 and referred to the years 1954–56. The new arrangement under the 1954 Act whereby H.M. Inspectors report annually on all mines and quarries in their division is more convenient in many ways than the former biennial reports.

The new reports show that particular attention is being paid at quarries to dust prevention and dust suppression and to encouragement in the use of protective clothing, especially safety hats, which many quarrymen seem loath to wear.

S. G. Ward

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* Reports of H.M. Inspectors of Mines and Quarries under the Mines and Quarries Act, 1954, for 1957. Northumberland and Cumberland Division. By H. Hyde. Pp. iv+41+6 plates. 3*s*. 6*d*. net. Scottish Division. By W. Widdas. Pp. iv+41+6 plates. 4*s*. net. North Western Division. By G. Hoyle. Pp. ii+42+6 plates. 3*s*. 6*d*. net. Durham Division. By W. Brown. Pp. iv+23. 2*s*. 6*d*. net. South Western Division. By T. A. Jones. Pp. iv+28+4 plates. 2*s*. 6*d*. net. West Midland and Southern Division. By J. E. Henshaw. Pp. iv+34+2 plates. 3*s*. net. North Eastern Division. By C. W. Scott. Pp. ii+44+7 plates. 3*s*. 6*d*. net. East Midland Division. By W. B. Brown. Pp. ii+38+7 plates. 3*s*. 6*d*. net. (London: H.M. Stationery Office, 1958.)

PRESSURE WELDING OF METALS

Welding engineering is a profession now well established in industry and is supported by a research association and a technical institute. In Britain (unlike the United States and the U.S.S.R.) it has not achieved independent status at any university, and it is therefore practised by metallurgists and mechanical, electrical and civil engineers, in whose training it has occupied a very subsidiary role. However, as a result of the division of metallurgy into physical and industrial aspects at the University of Birmingham, research into and the teaching of the basis of metallic jointing practice now figures prominently in the Department of Industrial Metallurgy. To supplement the academic work, occasional conferences are organized to promote the exchange of information and ideas with other workers in the field. The second of these conferences, on the pressure welding of metals, was held on June 19, under the chairmanship of Prof. E. C. Rollason, head of the Department of Industrial Metallurgy, and was attended by ninety representatives of industry, the research associations and the universities.

After explaining the purpose of these conferences, Prof. Rollason reviewed the origins and development of the practice of pressure welding and the progress that had been made towards establishing a theoretical model. Three papers were then presented, the first by Mr. J. A. Donelan (Research Laboratories, General Electric Co.) dealt with industrial practice, the second by Messrs. L. R. Vaidyanath, M. G. Nicholas and D. R. Milner gave an account of the researches being carried out at the University of Birmingham, and the third paper by Dr. E. Holmes (University of Nottingham) was concerned with the relative importance of movement at the interface, oxide break-up, and the deformation of surface asperities upon bond formation.

The idea of joining metals by pressure is not new, as it has been employed in the hammer-forged blacksmith's weld from the earliest days of the use of iron; this, however, is a special case in that it depends on the squeezing out of a molten layer of slag between the two components to be joined. The general practice of pressure welding metals, without melting, was established in 1887 with resistance heating used to aid the deformation of the interface; then, during the Second World War, the cold welding process was developed in which metals are joined at room temperature. The majority of metals can now be pressure welded, if not at room temperature, then at higher temperatures. The advantages of the process are that the joint possesses none of the weaknesses inherent in the cast structure associated with the more normal welding techniques, and it is the only metallic jointing process that can be carried out at room temperature, and is therefore particularly suitable to the canning of delicate components such as detonators or transistors. One of the widest applications of pressure welding is to the production of ply metals by rolling, so that the advantages of the properties of two or more metals or alloys can be combined, for example, to provide corrosion resistance, as in the cladding of high-strength aluminium alloys with a thin layer of super-purity aluminium, or for economical reasons as in the cladding of mild steel with a thin layer of stainless steel.

Pressure welding practices developed empirically, and it was soon found that metals varied markedly in their welding characteristics, the criterion of weldability usually adopted being the amount by which two pieces of metal when placed together have to be deformed in order for them to join : thus, for example, at room temperature overlapped strips of tin and lead require a reduction in thickness of about 20 per cent, aluminium and copper 50 per cent, and nickel and iron 80 per cent. Cold welding is largely applied to aluminium and copper, and Mr. Donelan cited many applications in the electrical industry such as joining the ends of wires and rod, the formation of cable sheath from strip, and the fabrication of electric kettles and refrigerator coolant panels. Mr. Donelan stressed that for successful welding the most important factors are the surface preparation of the material (a degreasing treatment followed by scratch brushing being preferred), and the shape of the deforming tool.

The understanding of the phenomenon of pressure welding lags behind its practice and no satisfactory theory has been developed, although several hypotheses have been advanced as to the nature of the controlling parameter. When pressure welds could only be made at high temperatures it was considered that diffusion at the interface was essential to bring the surfaces into atomic contact, and for this reason that welding was enhanced at the recrystallization and transition temperatures, at which the rate of diffusion was considerably increased. With the advent of cold pressure welding emphasis was transferred from the influence of the temperature of welding to the pressure applied, which then came to be regarded by some workers as the controlling factor. These hypotheses, however, take little account of the practical necessity for careful surface preparation before welding, and more recent theories have concentrated on this aspect, in one case the penetration and fragmentation of the oxide film being regarded as critical, whereas in another case the difficulty of bringing roughened surfaces into intimate contact has been stressed. An alternative hypothesis has been advanced which implicitly assumes that the formation of bonds presents no difficulty, but that on release of the applied load these bonds are at least partially broken apart by elastic recovery forces which vary from one metal to another. Finally, there is the possibility of relative movement between the joining surfaces which, as workers in the field of friction have shown, leads to the formation of welds that are responsible for frictional restraint. None of the models suggested has been developed in detail and none of them can explain all the observed facts.

The difficulties in making an analysis of bond formation are : first, the large number of parameters involved ; and second, the fact that no satisfactory method has been developed for the measurement of the degree of bonding or weld strength which is obtained. Part of the theme of the work of Vaidyanath, Nicholas and Milner was that the mechanism of pressure welding is best investigated via the roll bonding process, since for practical purposes the reduction is uniform throughout the composite and it is possible to measure the bond strength by a test giving results which are more amenable to analysis than those available hitherto. This work has led to the development of a theoretical model for the maximum joint strength that can be obtained from the concept that oxide films are completely brittle, so that when the interface is extended, areas of virgin metal are exposed and these are the sources of potential bonding. However, the problem remains of why these virgin metal areas do not always join. From evidence on the effect of pressure, time, temperature, and exposure of the surface to the atmosphere prior to rolling, the authors concluded that a correct theory must involve considerations of atomic movements during deformation, diffusion and the solution of entrapped gases.

When dissimilar metals are welded, further problems arise in that if the two metals possess different mechanical properties they will not deform in the same manner and, in addition, alloy layers will develop at the interface and have a marked effect on the joint strength. Dr. Holmes showed that when dissimilar metals are bonded by rolling there will also be relative movement between the two surfaces as they enter the roll gap and that this could lead to substantial bonding without much deformation, the bond strength increasing with the amount of relative movement and with the applied load under which the movement was carried out. From further experiments, designed to examine the relative importance of the difficulty of bringing rough surfaces into intimate contact and that of penetrating the oxide film, Dr. Holmes reached the conclusion that for conditions under which the flow of metal was restrained oxide break-up was difficult to obtain, whereas, since restraint of necessity involves higher pressures, the deformation of asperities was readily achieved. Conversely, for conditions of low restraint, metal flow and oxide break-up took place readily and the deformation of the surface asperities became the controlling process.

The points raised during the discussion showed that pressure welding is contributing to the solution of some of the problems arising from modern technical developments, two examples of the use of cold welding being the joining of the trans-Atlantic cable and the fabrication of complex patterns of frozen mercury for precision casting. The disadvantage remains that in many cases considerable deformation is required, but a recent development has shown that this can be very much reduced by the application of ultrasonic vibration during the welding process. The use of impact loading was also discussed, but the results were inconclusive ; some indicated little difference, while others suggested considerable improvements, from the bond strengths obtained by deformation at conventional speeds. The divergence of the opinions expressed on the theory of pressure welding showed how little can be regarded as universally acceptable, and the ultimate answer will probably show that the controlling parameter varies with the conditions of welding. The technique of surface preparation prior to welding received considerable discussion, and it is found that the best welds are achieved with scratch-brushed surfaces : with many other surface treatments, or no surface preparation, it is often impossible to obtain any bonding. That no satisfactory explanation could be offered for the success of the scratch-brushing practice demonstrated again the inadequacy of the present state of the theoretical treatments of the subject.

D. R. Milner

USE OF ARTIFICIAL SATELLITES TO EXPLORE THE EARTH'S GRAVITATIONAL FIELD: RESULTS FROM *SPUTNIK* 2 (1957β)

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IT is well known that the Earth's oblateness and its atmosphere cause the main perturbations to the orbit of a near Earth-satellite, and various theoretical studies of these effects have been made. Now that accurate observations of satellite orbits are available it becomes possible, at least in principle, to reverse this procedure and to use the theories to obtain a better knowledge of the atmosphere and the Earth's gravitational field. This article gives some tentative conclusions about the gravitational field, after a comparison of theory with observation for *Sputnik* 2 (1957β).

Fortunately, it happens that the first-order perturbations due to the atmosphere and the Earth's oblateness are of different kinds: the air drag steadily reduces the length of the major axis and the eccentricity of the orbit[1], while the Earth's oblateness causes the orbital plane to rotate about the Earth's axis and the major axis of the orbit to rotate in the orbital plane. The rotation of the major axis is difficult to determine; but, as Buchar[2] has remarked, the rotation of the orbital plane, which can be measured very accurately, should provide new information about the gravitational field.

The gravitational potential U due to the Earth at an exterior point distant r from the centre may be expressed in spherical harmonics $S_n(\theta,\varphi)$ as:

$$U = \sum_{n=0}^{\infty} A_n r^{-n-1} S_n(\theta,\varphi) \qquad (1)$$

where θ is the angle between the radius vector and the Earth's axis (the co-latitude), φ is the longitude and the A_n are constants. If the potential is assumed to be independent of longitude and the equatorial plane is suitably chosen, equation (1) may be written more explicitly as:

$$U = \frac{fM}{R}\left\{\frac{R}{r} - \sum_{n=2}^{\infty} J_n\left(\frac{R}{r}\right)^{n+1} P_n(\cos\theta)\right\} \qquad (2)$$

where f is the gravitational constant, M the mass of the Earth, and R the Earth's equatorial radius. P_n is the Legendre polynomial of order n and the J_n are constants. Of the coefficients J_n, only J_2 is at present known at all accurately, and it is customary to express U in the form recommended by Jeffreys[3] as:

$$U = \frac{fM}{R}\left\{\frac{R}{r} + J\left(\frac{R}{r}\right)^3\left(\frac{1}{3} - \cos^2\theta\right) + \frac{D}{35}\left(\frac{R}{r}\right)^5(35\cos^4\theta - 30\cos^2\theta + 3)\right\} \qquad (3)$$

where the coefficients J and D are related to the J_n of equation (2) by $J = \frac{3}{2}J_2$ and $D = -\frac{35}{8}J_4$.

The geopotential Ψ is obtained by adding a term $\frac{1}{2}w^2 r^2 \sin^2\theta$ to U, to allow for the angular velocity w of the Earth, and Jeffreys chose the coefficient D in (3) to make the value of Ψ constant over a spheroid of equatorial radius R and polar radius $R(1 - \varepsilon)$, which was taken as an approximation to the real Earth, with ε as the polar flattening. With these assumptions:

$$J = \varepsilon - \frac{m}{2} - \varepsilon\left(\frac{\varepsilon}{2} - \frac{m}{7}\right) + 0(\varepsilon^3) \qquad (4)$$

and

$$D = \frac{\varepsilon}{2}(7\varepsilon - 5m) + 0(\varepsilon^3) \qquad (5)$$

where $m = R^3w^2(1 - \varepsilon)/fM$ is the ratio of centrifugal to gravitational acceleration at the equator, multiplied by $(1 - \varepsilon)$. The value of m is accurately known ($10^6 m = 3449{\cdot}79 \pm 0{\cdot}06$), while from geodetic measurements Jeffreys deduced that $J = 0{\cdot}001637 \pm 0{\cdot}000004$, which gives $1/\varepsilon = 297{\cdot}1 \pm 0{\cdot}4$. Then from (5), $D = 10{\cdot}6 \times 10^{-6}$.

The mean rate of rotation of the orbital plane, $\dot{\Omega}$, for a near satellite in the gravitational field defined by (3) is found[4] to be:

$$\sqrt{\frac{fM}{a^3}}\left(\frac{R}{\bar{r}}\right)^2 \cos\alpha\left[J + J^2\left(\frac{R}{\bar{r}}\right)^2\left(\frac{19}{12}\sin^2\alpha - 1\right) - \frac{3DR^2}{14\bar{r}^2}(7\sin^2\alpha - 4) + 0(J^2e)\right] \qquad (6)$$

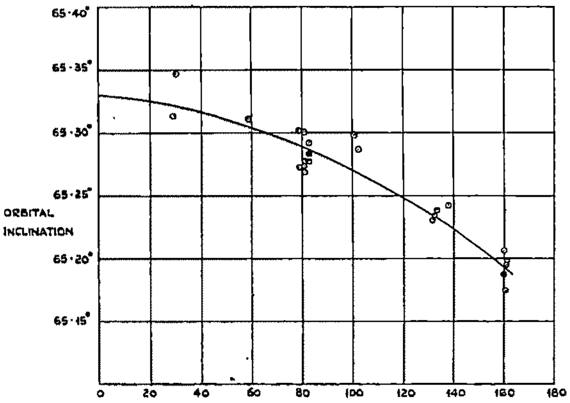

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Fig. 1. Mean orbital inclination of *Sputnik* 2 (1957β)

in the opposite direction to the satellite's motion, where a is the semi-major axis of the orbit, $\bar{r}$ the semi-latus rectum, e the orbital eccentricity and α the mean inclination of the orbital plane to the equator.

The expression (3) for U implies that the Earth is symmetrical about the equatorial plane. In considering the observational results, however, it is as well to remove this restrictive assumption and to include the third harmonic, a term:

$$\frac{fM}{R} J_3 \left(\frac{R}{r}\right)^4 \tfrac{1}{2}(5 \cos^3 \theta - 3 \cos \theta)$$

on the right-hand side of (3). It has been found (Merson, R. H., and Plimmer, R. N. A., unpublished work) that this gives rise to an extra term:

$$-\frac{3}{8}\sqrt{\frac{fM}{a^3}}\left(\frac{R}{\bar{r}}\right)^3 J_3\, e \sin \omega \cot \alpha \,(15 \sin^2 \alpha - 4) \quad (7)$$

in (6), where ω is the mean argument of perigee.

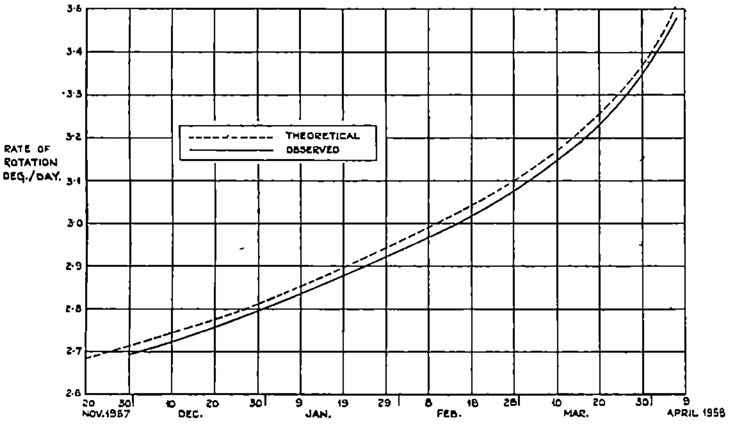

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Fig. 2. Rate of rotation of orbital plane of *Sputnik* 2

In the theoretical formula for $\dot{\Omega}$, as given by (6), the value of $\cos \alpha$ is much less accurately known than the other factors outside the square brackets, and in comparing the theoretical and observed values of $\dot{\Omega}$, it is this uncertainty in $\cos \alpha$ which sets the limit to the accuracy. The value of α for *Sputnik* 2 has been determined from a series of kinetheodolite observations made at Ministry of Supply stations at Aberporth, Bramshot, Larkhill, Orfordness and West Freugh. These have been analysed using a Pegasus digital computer at the Royal Aircraft Establishment (the method of analysis is described elsewhere[5,6]) and the results are plotted in Fig. 1. It is found that

$$\alpha = 65{\cdot}331° - 0{\cdot}00018°\, t - 0{\cdot}0000043°\, t^2 \pm 0{\cdot}02° \quad (8)$$

where t is the time in days after November 3·0, 1957.

This marked decrease in α, at the rate of about 0·001 deg./day, has not yet been satisfactorily explained. The theoretical formula for $\dot{\alpha}$ for an orbit *in vacuo* contains terms in J_3e, De^3 and J^2e. The value of $\dot{\alpha}$ given by this formula does not appear to be large enough to account for the observed change, however. Also, if the decrease were due to the J_3e term, the rate of decrease should tend to zero at the end of the life-time of the satellite when $e \to 0$, whereas Fig. 1 indicates that the decrease becomes sharper towards the end. This suggests that the change may be due to some second-order effect of the atmosphere, and possible causes, such as rotation of the atmosphere, are being investigated.

The theoretical value of $\dot{\Omega}$ during the life-time of *Sputnik* 2 has been calculated from the expression (6), using the values of J and D recommended by Jeffreys[3], values of α from (8), and values of other orbital elements derived from kinetheodolite observations and from theodolite observations made at Jokioinen, Finland. At the same time, observed values of Ω, the right ascension of the ascending node, have, after suitable curve-fitting, been differentiated and values of $\dot{\Omega}$ (observed) have been obtained. Fig. 2 shows the variation with time of the theoretical and observed values of $\dot{\Omega}$. It was found that the ratio $\dot{\Omega}$ (theoretical)/$\dot{\Omega}$ (observed) remained virtually constant during the life-time of *Sputnik* 2 and had the value 1·0068 ± 0·0003.

Since this ratio remained so nearly constant, it seems highly improbable that the discrepancy is due to atmospheric effects, which should increase steadily as time goes on. The effect of the J_3 term can also be discounted since the factor $e \sin \omega$ in (7) decreases markedly during the life-time of the satellite. A change in either J or D, however, would change $\dot{\Omega}$ by a nearly constant factor, because the ratio of the J-term to the D-term in (6) does not vary by more than 10 per cent during the life-time of the satellite. It therefore seems probable that one or both of the constants J and D is in need of revision.

The discrepancy between the observed and theoretical values of $\dot{\Omega}$ could be explained either by a change in J from 0·001637 to 0·001626 (corresponding to a change in $1/\varepsilon$ from 297·1 to 298·1 ± 0·1), or by a change in D from $10{\cdot}6 \times 10^{-6}$ to 45×10^{-6}. How the changes should be apportioned between J and D can best be decided by accurate observations on a satellite with different orbital inclination. The preliminary information so far available to us on the first of the three U.S. satellites, which had inclinations near 35°, suggests that the observed values of $\dot{\Omega}$ are, as for *Sputnik* 2, lower than the theoretical. Since the D term in (6) changes sign when α changes from 65° to 35°, it seems likely that the discrepancy is due mainly to the J-term and that J needs to be reduced, though not necessarily to the value given above.

We wish to thank the kinetheodolite observers of the Ministry of Supply, and Dr. G. Järnefelt, of the Jokioinen Meteorological Observatory, Finland, for providing the observations on which these results are based.

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AN APPARATUS FOR MICROELECTROPHORESIS OF SMALL PARTICLES

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Introduction

THE most widely used apparatus for electrophoresis of small particles have employed either rectangular[1–4] or cylindrical[5–9] chambers. The former has gained more adherents recently because of the optical difficulties[10,11] associated with cylindrical designs. The apparatus now described has been developed especially for studying the surface properties of tissue cells where rapid measurement and accurate temperature control are required.

Three features of this apparatus distinguish it from others previously used: (1) The tube is fixed permanently in position and is washed out *in situ*. (2) A dial test indicator is incorporated, allowing the microscope to be rapidly focused at the correct level independent of any inaccuracies in the fine adjustment screw. (3) The objective and electrophoresis tube are immersed in water, which simplifies temperature control and reduces the refraction by the cylindrical lens of the capillary wall. A reading can be taken and the tube cleaned in five minutes. The readings are reproducible to within 3 per cent. The apparatus is simple, robust and easy to construct.

Theory of the Cylindrical Cell

There are two electrokinetic effects in a closed glass tube containing a suspension of particles in an applied electric field. There is motion of the particles with respect to their suspending medium (electrophoretic effect) and a movement of liquid relative to the wall of the capillary (electro-osmotic effect) with a return flow of liquid down the centre of the tube. This produces a parabolic distribution of particle velocities across the diameter of the tube. The mobility of particles is measured at the stationary level, the position of which is derived below.

Lamb[12] has shown that for the closed cylindrical tube:

$$V_w = \frac{P}{4\eta}\,(r^2 - \tfrac{1}{2}R^2) \tag{1}$$

where V_w is the velocity of the liquid, P the hydrostatic pressure gradient parallel to the axis, η the coefficient of bulk viscosity of the liquid, and r the distance from the axis of the tube of radius R. The velocity at the surface of the tube $V_s = PR^2/8\eta$; hence (1) may be written:

$$V_w = V_s\,(2r^2/R^2 - 1) \tag{2}$$

The observed velocity V_0 of a particle is equal to $V_e + V_w$, where V_e is the electrophoretic velocity, hence:

$$V_0 = V_e - V_s + V_s\,(2r^2/R^2) \tag{3}$$

so that the velocity of a droplet is a linear function of the square of its distance from the axis of the tube.

Now $V_w = 0$ when $2r^2 = R^2$ or $r = R/\sqrt{2}$ (stationary level condition). Hence $r = 0{\cdot}707R$ from the axis or $0{\cdot}293R$ from the wall of the tube.

To ensure that all readings are taken at the stationary level, either that level alone is illuminated or, as in the present equipment, the microscope is set so that only the particles at the stationary level are in focus.

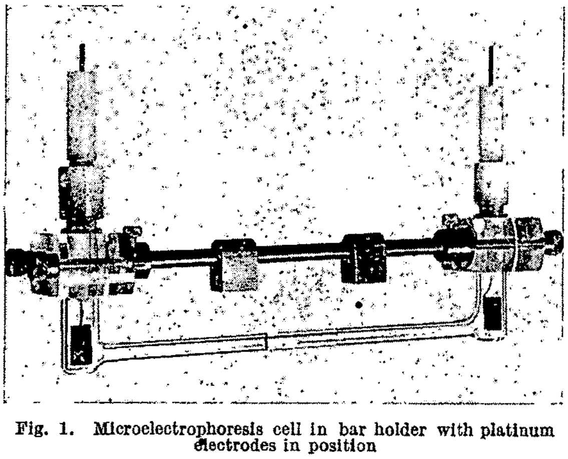

Fig. 1. Microelectrophoresis cell in bar holder with platinum electrodes in position

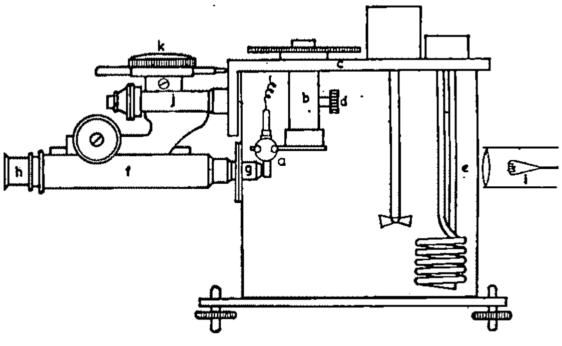

Fig. 2. Microelectrophoresis apparatus. *a*, tube holder; *b*, calibrated vertical traverse; *c*, crossbar; *d*, locking screw; *e*, thermostat; *f*, microscope tube; *g*, objective; *h*, micrometer eyepiece; *i*, light source; *j*, microscope fine adjustment; *k*, dial test indicator

Henry's correction[10] applied to the chamber of 'Veridia' glass (refractive index 1·47) amounts to 0·12 *R* when focusing is performed in air and is reduced to 0·01 *R* by immersing the objective in water.

Because of its rotational symmetry the mathematical expression of the velocity distribution for a cylindrical tube is more exact than that for the rectangular chamber where no theoretical correction for perturbation in the electro-osmotic flow produced by the side walls is made. In addition, symmetrical exchange of heat across the wall of the tube will tend to minimize convection currents.

The apparatus is illustrated in Figs. 1 and 2.

The Microelectrophoresis Tube

The tube consists of a cylindrical precision capillary of 'Veridia' glass; internal diameter uniform to ± 0·01 mm. The exact internal diameter chosen depends on the working distance of the objective; a diameter from 2·0 to 3·0 mm. is suitable for use with most × 40 objectives. At less than 1·5 mm. diameter the change in mobility of particles with depth in the tube is very large in the stationary level region, leading to large errors in mobility determinations for only small setting errors. Thermal convection effects are readily produced in tubes greater than 3·0 mm. in diameter because of the greater current flowing per unit field strength. A capillary tube of about 150 mm. was chosen since this length is convenient for levelling the cell accurately. There is no risk of contamination by electrode products since a current flowing for five times as long as is required for a mobility determination leads to contamination of approximately only the first 2·0 mm. of each end of the capillary.

'Quickfit and Quartz' *B*10 'Pyrex' sockets were fused to each end of the capillary tube and the viewing region formed by grinding and polishing a flat on the capillary wall. The capacity of the apparatus is approximately 5·0 ml. For the examination of very small quantities a similar tube fitted with *B*7 joints with a capacity less than 2·0 ml. is used. Electrodes of grey platinum[13] are inserted into the *B*10 'Pyrex' sockets. They consist of platinum foil of dimensions 12·5 × 20·0 mm., so that the current density is sufficiently low to obviate serious risk of polarization. The foil is formed into a cylinder and welded on to platinum wire which is inserted into a reservoir of mercury through a *B*10 soda glass or polyethylene plug. Reversible silver/silver chloride or copper/copper sulphate electrode systems were not used because of their greater complexity and the risk of contamination of the suspension with copper or silver salts. For currents less than 2·0 m.amp. reliable results can be obtained from these irreversible electrodes.

The Tube Holder

The tube is fixed horizontally in a holder (in Fig. 2,*a*) attached to a calibrated vertical traverse (*b*) (reading to 0·01 mm.) mounted on a crossbar (*c*) on the water-bath. A locking device (*d*) is incorporated in the adjustable traverse. Both tube and holder are immersed in a glass or 'Perspex' water-bath, the temperature controlled to ± 0·1° with an immersion heater (500 kW.) and a toluene regulator and 'Sunvic' switch or any other thermostatic device (*e*). The tube is set so that its capillary lies parallel to the surface of the water in the bath. Cleaning is effected *in situ* using a polyethylene cannula and a suction pump. When systems of low ionic strength are used, chromic acid cannot be employed with safety as a cleaning agent unless time is allowed to leach the adsorbed chromate ions from the glass wall of the cell. A molar solution of sodium chloride is used for rinsing out between determinations at low ionic strength ($< 0{\cdot}01$).

The Microscope

The microscope tube, 160 mm. long (Fig. 2,*f*), attached horizontally to the crossbar (*c*), is fitted with a × 40 $\frac{1}{8}$-in. waterproofed objective numerical aperture 0·7 (*g*), and a × 10 micrometer eyepiece (*h*) incorporating a chessboard graticule (5 × 5 squares of 0·25 mm. side). The optical system gives a magnification of 400 diameters and is calibrated against a 1·0 mm. standard micrometer scale divided to 0·01 mm. The depth of focus is about 0·005 mm.

A light source (*i*) is conveniently mounted behind the water-bath at right angles to the tube and co-axial with the objective. The objective is inserted into the bath through a water-tight rubber gasket and can be focused on the optical flat of the tube or on the stationary level using the horizontal fine adjustment of the microscope (*j*).

An adjustable zero dial test indicator (*k*) reading to 0·002 mm. is mechanically linked to the fine adjustment of the microscope (*j*) and bears on the crossbar (*c*) to give rapid and accurate reading of the objective setting.

The rate of movement of the particles is found by timing them (stop-watch reading 0·1 sec.) over a fixed number of graticule divisions selected so as to give a reading of about 10 sec. at an applied potential gradient of 3–5 V. cm.$^{-1}$. The direction of the current is reversed half-way through each reading to minimize polarization. A mobility value is normally based on determinations on ten individual particles and is expressed in μ sec.$^{-1}$ V.$^{-1}$ cm.$^{-1}$.

Circuit

This is shown in Fig. 3. A 150 V. radio battery supplies the potential through an on/off switch to the 25 *k* linear potentiometer (*P*1) which acts as a potential divider. (*V*) is a Braum 0–100 μamp. centre–zero micro-ammeter with a top grade 1·0 megohm resistor (*R*) and a 100 *k* linear carbon potentiometer (*P*2) in series to give a 0–200 V. direct-reading high-resistance voltmeter. (*A*) is a Pye 'Scalamp' (7901/5) shunted galvanometer, sensitivity 15·6 mm./μamp. on direct reading position. The two-way double pole switch (*D*) is wired for reversing the polarity of the electrophoresis cell, but not that of the meters in the circuit.

The potential gradient was obtained directly using the applied potential and the distance between the electrodes and indirectly using the relationship field strength $F = I/KA$, where A is the cross-sectional area, I is the current passing through the tube, and K the specific conductivity of the dispersion. The two methods were found to be in excellent agreement for the systems tested.

Experimental

Since the electrophoretic mobility for washed human and sheep erythrocytes (0·1 per cent v/v suspension) in 0·145 *M* sodium chloride with added 0·145 *M* hydrochloric acid or sodium hydroxide is

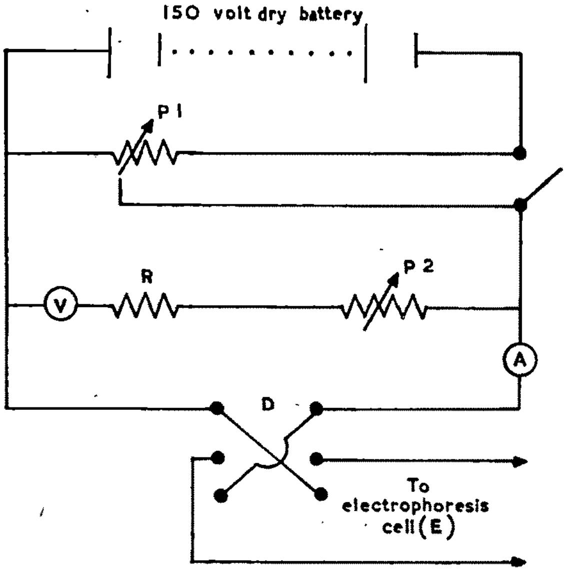

Fig. 3. Circuit diagram. *P*1, 25 *k* linear potentiometer; *P*2, 100 *k* linear potentiometer; *R*, 1 megohm resistor; *A*, galvanometer; *V*, centre-zero high-resistance voltmeter; *D*, reversing switch

constant over the *p*H range 5·0–9·0 [14], it is possible to locate the stationary level experimentally as the point of intersection of a series of *p*H depth-mobility curves (see Fig. 4). For the cylindrical tube it is also found that the relationship between velocity of the particle and the square of the displacement from the axis is linear, as predicted by equation 3 (see Fig. 5).

The stationary level is thus found by calculation and experiment and the mobility of human red cells in phosphate buffer *p*H 7·4 (2·0 ml. *M*/15 KH_2PO_4 + 8·0 ml. *M*/15 $Na_2HPO_4.12H_2O$) was 1·28 ± 0·03 μ sec.$^{-1}$ V.$^{-1}$ cm.$^{-1}$ and in 0·145 *M* sodium chloride solution it was 1·07 ± 0·02 μsec.$^{-1}$ V.$^{-1}$ cm.$^{-1}$. Table 1 shows a selection of the most reliable results obtained by other authors for the phosphate and chloride systems. Other observations in the literature do not deviate by more than about 5 per cent from those quoted, if those which can be traced to some error in technique are excluded. The difference between the chloride and phosphate values is attributed to greater anion absorption in the partially divalent phosphate case. The results under the above conditions are extremely reproducible and are independent of race, sex, age or blood group.

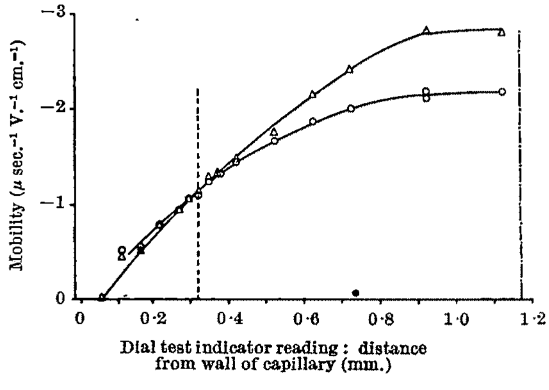

Fig. 4. *p*H-depth-mobility curves for human red blood cells. Δ, *p*H 9·0; O, *p*H 6·5; ———, stationary level; —•—·—·—, axis of tube

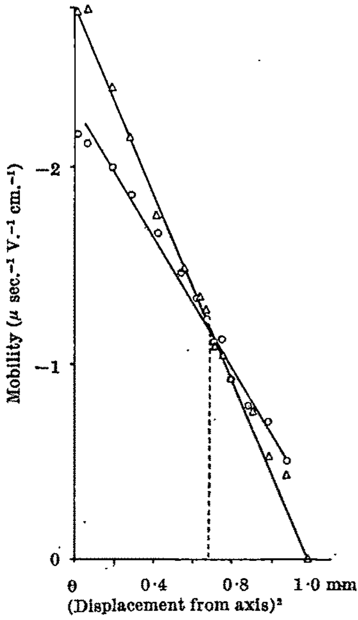

Fig. 5. Mobility–(displacement from axis)^2 relationships for human red blood cells: Δ, *p*H 9·0; O, *p*H 6·5; – – –, stationary level

Table 1. ELECTROPHORETIC MOBILITY OF HUMAN RED CELLS AT *p*H 7·4 AND 25° C.

Ref.	Electrophoretic apparatus	Suspending medium	Ionic strength	Mobility μ sec.$^{-1}$ V.$^{-1}$ cm.$^{-1}$
2	Rectangular (horizontal position)	Phosphate	0·172	1·30
3	Rectangular (lateral position)	Phosphate	0·172	1·27
4	Rectangular	Phosphate	0·172	1·31 ± 0·02
15	Cylindrical	Phosphate	0·172	1·32 ± 0·05
16	Rectangular	Phosphate	0·172	1·28
16	Rectangular	Chloride	0·145	1·07 ± 0·02
17	Rectangular	Chloride	0·145	1·10

We wish to thank Prof. J. S. Mitchell, Sir Alan Drury and Dr. B. A. Pethica for their support, the Elisabeth Storey Fund (D. H. H.) and the Lady Tata Trust (G. V. F. S.) for financial grants, and A. Bernard for technical assistance.

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PERCHLORATE, AN IMPORTANT CONSTITUENT OF SEA WATER

By L. G. M. BAAS BECKING, A. D. HALDANE and DAVID IZARD

Commonwealth Scientific and Industrial Research Organization and Bureau of Mineral Resources, Canberra

PERCHLORATES, together with iodates and chromates, are known to occur in the Chilean nitre-beds[1-4]. Goldschmidt[3] suggested that these "final products of oxidative weathering" might also occur in other nitre deposits and, perhaps, in the evaporite environment in general. It now appears that both iodates and perchlorates are of widespread occurrence in the natural environment. This article is confined to the consideration of the perchlorates.

The reason why the presence of these oxyhalides has hitherto escaped attention must be ascribed in part to the inadequacy of the analytical methods[5-9]. We have tested most of the reagents described in the literature and the reproducibility of their reactions. Many of the tests for perchlorate suffer from grave disadvantages and have not been sufficiently investigated. There are reagents, like copper pyridine[10], that may yield positive results with pure perchlorate solutions but are of no use when the sample contains high concentrations of other salts. Some reagents seem to be of variable composition. This is particularly the case for reagents which are oxidized by perchlorate, such as α-naphthol, resin of guaiac (guaiacol is always inactive), *p*-phenylene-diamine and hæmatoxylin[11]. It is difficult to obtain two samples of these reagents that react in a similar fashion with perchlorate. Perchlorates are reported to react with amines. We found that no insoluble compounds were formed either with hydroxylamine or with hydrazine. It is possible that perchlorates will enter into combination with the amines occurring in the estuarine environment[12]. About most of the other reagents we will remain silent, as it would take too long to discuss their respective disadvantages[5,6].

After much trial and error we were left with three adequate presumptive tests and with two quantitative methods.

(*a*) *The 'char-reaction'*. In drying paper chromatograms it was discovered that perchlorates, in an acid environment, lower the char-temperature of the filter paper. With Whatman paper No. 544 the following results were obtained:

	Char temperature	Time
No perchlorate	230° C.	Instantaneous
Perchlorate	170° C.	Instantaneous
Perchlorate	160° C.	15 sec.
Perchlorate	105° C.	12 min.
Perchlorate	85° C.	35 min.

Among other substances tested, only chlorates and copper ions behaved in a similar way. As chlorates were never found in the natural environment, copper alone might interfere in special circumstances. For a spot-test, the filter paper is pre-treated with a saturated solution of oxalic acid, and dried. A drop of the sample solution is spotted on to the paper, and if, after heating, a jet-black ring is formed the presence of perchlorate is indicated. In the presence of high concentrations of chloride ion the central area of the spot assumes a reddish-brown colour, which is readily distinguished from the black ring given by perchlorates. The spot test may be applied at concentrations of perchlorate greater than about 100 p.p.m.

Circular chromatograms on 10-cm. paper disks (Whatman No. 41), using alcoholic ammonia according to Lederer and Cohen[9], show, on heating, a black, well-defined ring in the presence of perchlorate at R_F 0·83–0·87, the position agreeing with that obtained by other reagents. Using 0·1-ml. drops, the sensitivity may increase to less than 100 p.p.m.

(*b*) *Formation of strychnine perchlorate*[5,8]. Strychnine sulphate crystals, when placed in a dilute solution of perchlorate, slowly become covered with a felt of hair-like prismatic crystals of the perchlorate. According to the literature, this reaction is specific. If the perchlorate concentration is too high, the strychnine sulphate crystals may become immediately and completely covered with the precipitate, thus blocking further reaction, and the typical appearance is not developed.

(*c*) *Methylene blue*[5,8]. Pure methylene blue chloride, free of zinc, yields with perchlorates a purple, crystalline precipitate. Persulphates (absent in the natural environment) and certain salts of heavy metals may interfere. Although not as specific as the strychnine reaction, it is extremely sensitive and requires only small amounts of perchlorate. The methylene blue reaction has been used in the quantitative determination of perchlorate. There are many difficulties. The results reported here were obtained by using: (1) high dilutions (40 p.p.m.) of freshly prepared pure methylene blue, allowing 20–30 min. for the reaction to become complete, and filtering off the precipitate on a sintered glass filter funnel; (2) equal volumes of 25 p.p.m. methylene blue and sample, allowing 30 min. for the reaction to be completed, after which the solution is centrifuged for 10 min. at 3,000 r.p.m. The methylene blue in the filtrate is determined colorimetrically with a Spekker absorptiometer, using a red filter. Less than 100 p.p.m. perchlorate may be determined in this way, which is very satisfactory when compared with other methods[6]. Further refinement may be obtained by shaking out the molybdenum perchlorate with *iso*propyl–methyl ketone. 1 p.p.m. potassium perchlorate may be detected in this way, using a 'Unicam' spectrophotometer. In the presence of chloride the distribution of the dye between the aqueous and the ketone layer is very slow; it takes several days before equilibrium is established. For this reason, the method has not been further investigated.

(*d*) Fusion with sodium carbonate will convert perchlorate to chloride, which can then be titrated with silver nitrate[13]. This method is suitable only for samples initially low in chloride ion. The removal of the initial chloride ion by precipitation with silver nitrate appears unsatisfactory when small amounts of perchlorate are involved.

(*e*) *Other methods*. No polarographic wave is obtained with perchlorate[14]. No X-ray patterns could be obtained with natural materials or with their concentrates. Goldschmidt[3] points out that in the natural evaporite salts the perchlorate ion probably enters the crystal lattice of gypsum and that this is the reason why no specific perchlorate mineral has been found, although it may be present in amounts of more than 6 per cent in the nitre[13]. Apart from this 'intralattice' effect in gypsum, perchlorates have a tendency to form 'interlattice' combinations with other salts, notably with sodium chloride. As no sufficiently insoluble inorganic perchlorates are known (potassium perchlorate is still fairly soluble), it seems difficult, if not impossible, to enrich a salt sufficiently to obtain an X-ray pattern of a perchlorate. Thus far we have not discovered potassium perchlorate crystals in natural waters, salts or concentrates. However, the strychnine compound could be prepared from a concentrate of a bittern from Dry Creek Salt Works (Imperial Chemical Industries, Ltd.), South Australia, supplied by Mr. C. W. Bonython. By comparing the X-ray pattern of this compound with strychnine perchlorate their identity was established by Mr. W. Roberts, of the Bureau of Mineral Resources. Inasmuch as the chemical tests on this brine concentrate are in harmony with the X-ray findings, we may now assume that substances yielding the presumptive tests described above are indeed perchlorates.

Occurrence of Perchlorates in Nature

The methods discussed above allowed us to establish the order of magnitude of the perchlorate content of various materials (Table 1). The quantities are often considerable—up to 5,600 p.p.m. in Lake Eyre brine, for example.

This is still less than one-third of the saturation value of potassium perchlorate at 20° C. Much analytical work has to be done before more reliable quantitative results are obtained.

Earlier in our work we obtained comparative results on chromatograms with *p*-phenylene diamine, hæmatoxylin and resin of guaiac for various sea-water samples.

After dissolving the blue oxidation product of guaiac resin (at R_F 0·83–0·87) in acetone, the red extinction was measured with a Lange photometer.

The results (Table 2) would suggest that the perchlorate content of sea-water tends to be highest near the coast and that it may decrease far from land and at great depths.

Table 1. CONCENTRATION OF PERCHLORATE ION IN PARTS PER MILLION IN VARIOUS MATERIALS

Not detected

Tapwater (Sydney and Canberra)
Rainwater (several samples)*
Lake Dobson (fresh). Tasmania
Wombat Moor (fresh). Tasmania
Geothermal waters. Rotarua district, N.Z.
Jenolan River, N.S.W.
Cotter River, A.C.T.
Murrumbidgee River, N.S.W.
Upper Hawkesbury River, N.S.W.

10–100 p.p.m.

Sea-water far from land (80 miles E. of Lord Howe Island)
Sea-water, 500 m. and 1,000 m. deep (same locality)
Lagoon, White Island, Bay of Plenty, N.Z.
Chlorinated distilled water
Chlorinated tap water
Many chemicals, analytical grade

100–1,000 p.p.m.

Estuarine and inshore waters (N.S.W. coast, Victoria coast, New Caledonia coast)
Coral reefs, Gouara, Oundjoh, Isle Charron (New Caledonia)
Mirabilite from Mawson Base, Antarctica (supplied by Mr. P. W. Crohn, A.N.A.R.E.)
Frome River (South Australia) flowing from a deep bore, pool with algae
Certain chemicals, analytical grade

1,000–10,000 p.p.m.*

Salt from Dry Creek, South Australia salt works.
Salt from Lake Eyre, 3–6 in. deep and 11 ft. 3 in. deep. Brines from Dry Creek and from Lake Eyre. Salt from Pink Lakes (Victoria), stored since 1936
Saltpetre, potassium bromate, commercial borax, commercial salt (solar)

* A faint trace in one sample

Table 2

Locality	Perchlorate (p.p.m.)
Gunnamatta Bay, Cronulla, N.S.W. Surface, in kelp beds	200–300
Gibbon, Cronulla, N.S.W. mouth off Port Hacking River, 100 m. deep	300
Ulladulla, N.S.W. Inshore, surface	150
Open sea, 80 miles E. of Lord Howe Island (from a cruise of the F.R.V. *Derwent Hunter*)	
Surface	100
100 m. deep	100
500 m. deep	30
1,000 m. deep	60

The conversion of the comparative figures to absolute figures is uncertain

Perchlorate Cycle

There is no reasonable doubt that iodide, bromide and chloride enter into a cycle forming, at one stage or another, higher oxidation levels. It has been unfortunate that in the literature the formation of the known oxyhalides seems to have been linked almost exclusively with the nitrogen cycle[2,3]. While nitrogen compounds may play a part in the formation of oxyhalides, there are many other ways in which these compounds may be formed. Although speculation on this matter seems premature, we should like to suggest one possibility which is in harmony with the data at our disposal.

The almost invariable occurrence of iodate (in particulate form) together with the perchlorate in both sea-water and salt suggests that the cycles of these halides are interconnected. We believe this iodate to be of biological origin, but as yet have not sufficient evidence to say this with certainty. Iodate formed directly from iodide or from elemental iodine may react with chloride to yield chlorine[4], some of which may then form perchlorate. We have found that, in the latter connexion, chlorinated distilled water contains perchlorate.

In sea-water the perchlorate is chiefly dissolved, but while none is held by a millipore filter (diameter 0·5μ), some perchlorate is retained by a Seitz asbestos filter. It may have been adsorbed by the asbestos, however. All the iodate is held by the millipore filter.

We are better informed on the breakdown of the perchlorate, at least in fresh-water. A butyric acid fermentation on malt reduced more than half a perchlorate solution (1,000 p.p.m.) in two weeks at 20° C. In the same time, a sulphate reduction brought a similar solution to 85 per cent of its original strength. Even in surface plankton swarms there may be foci of low potential in which this reduction could take place, as Mr. E. J. F. Wood (Commonwealth Scientific and Industrial Research Organization) has isolated both sulphate reducers and purple bacteria from surface phytoplankton (private communication).

Importance of the Halogen Cycle

(*a*) *Physiological.* Chili saltpetre, containing more than 0·5 per cent perchlorate, has long been known to be toxic to plants[13]. Experiments on the influence of perchlorates on growth and on germination are in progress.

(*b*) *Hydrology and oceanography*[15]. The potential variability of the perchlorate in sea-water may influence the chloride content. It has been observed repeatedly (C. Walker, Commonwealth Scientific and Industrial Research Organization, private communication) that the chlorinity of sea-water increased in the second decimal of the pro-mille chlorinity figure after storage. The order of magnitude of per-

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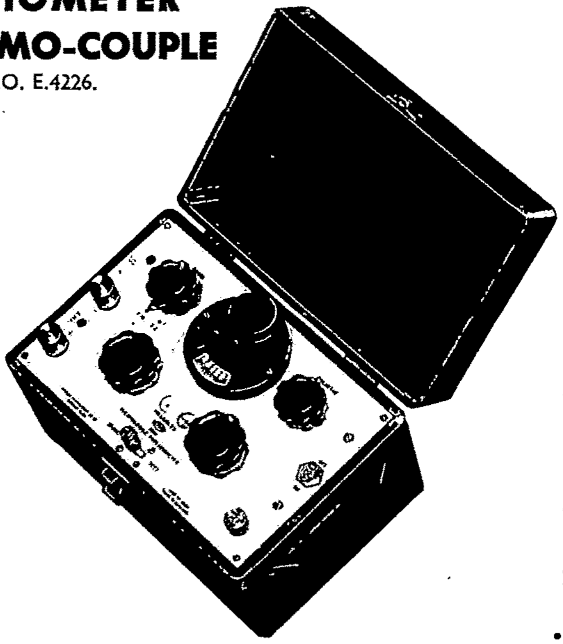

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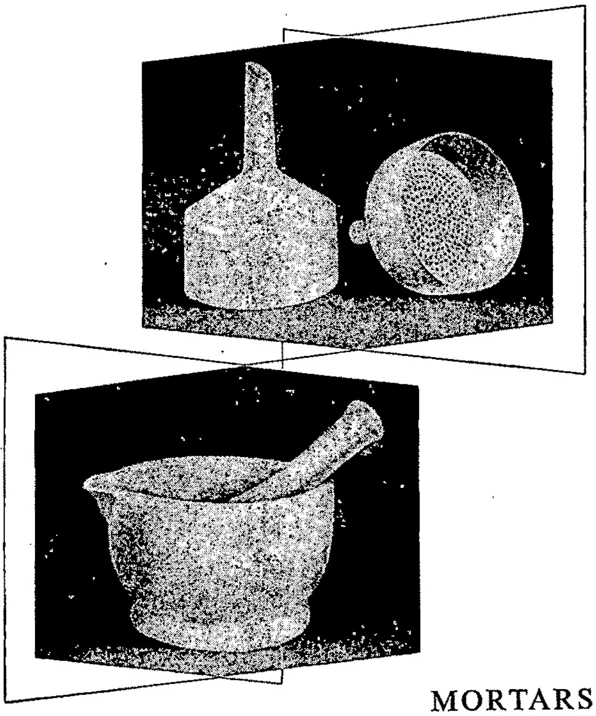

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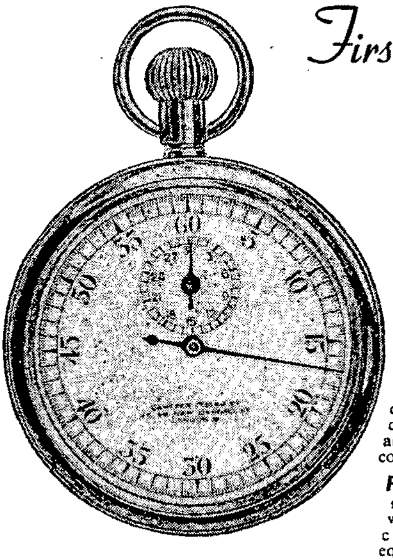

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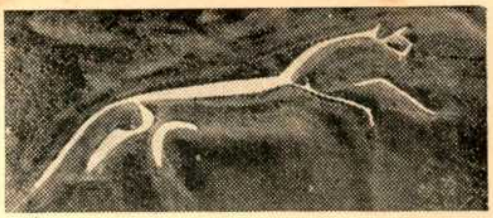

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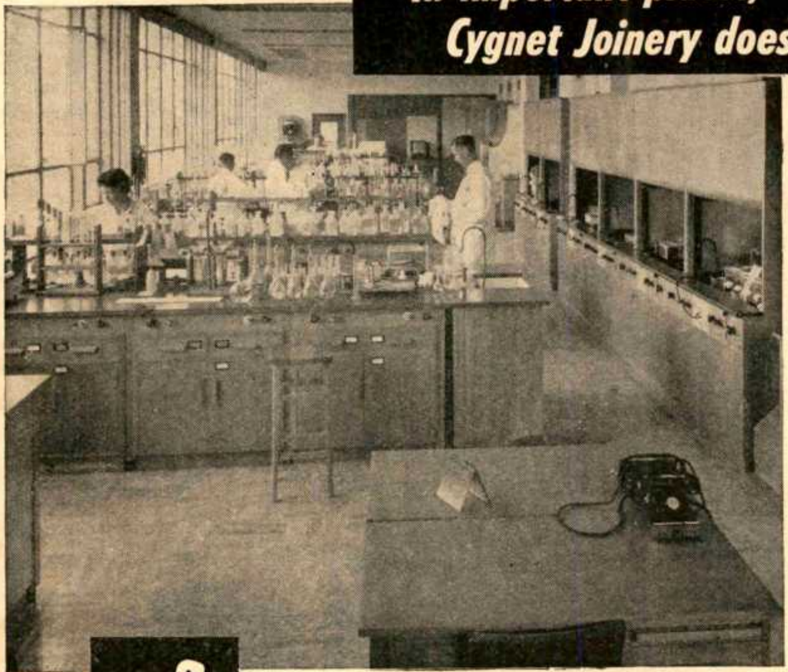

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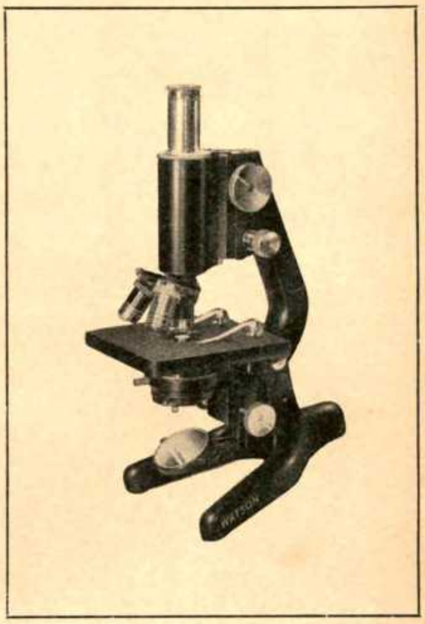

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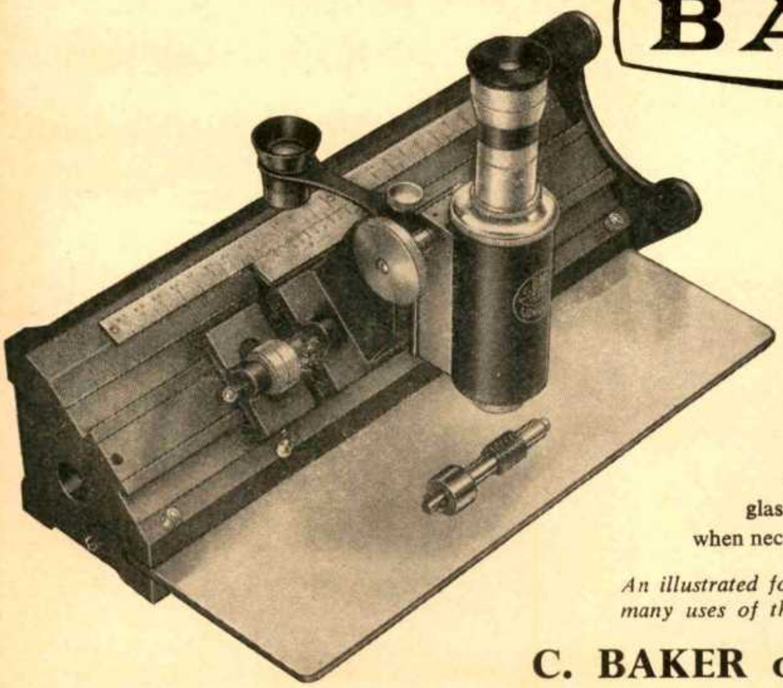

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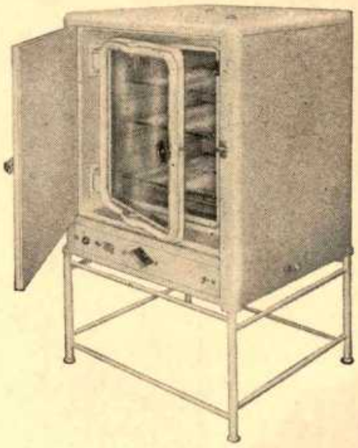

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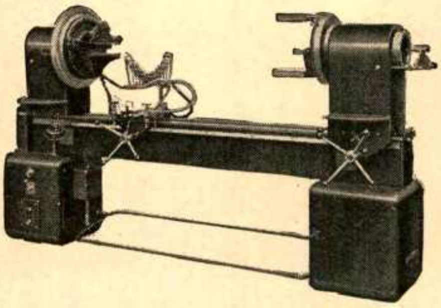

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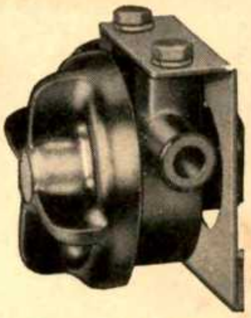

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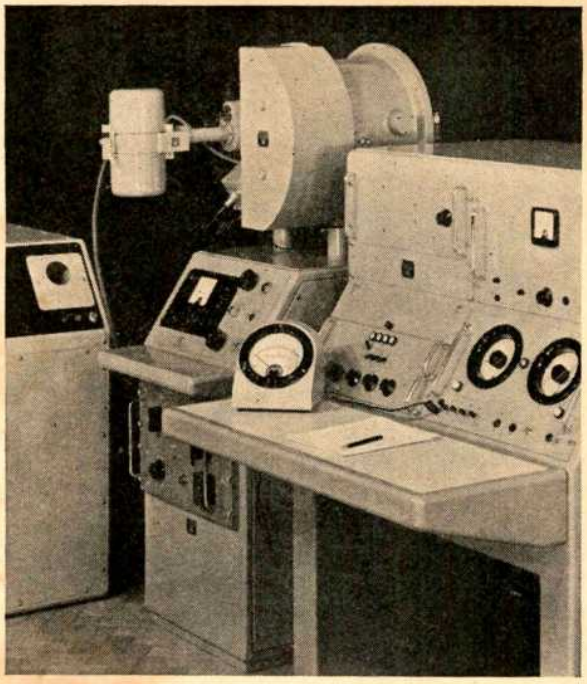

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Any study on oxidative weathering in saline environments has to take this possibility into account.

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FAILURE OF SORBITOL TO REPLACE INTRINSIC FACTOR IN THE GASTRECTOMIZED RAT

By DR. BERNARD A. COOPER*

Thorndike Memorial Laboratory and Second and Fourth (Harvard) Medical Services, Boston City Hospital, and the Department of Medicine, Harvard Medical School, Boston, Mass.

EVIDENCE has recently been presented that 'Liptril', a pharmaceutical preparation free of gastric intrinsic factor, may enhance the absorption of vitamin B_{12} from the gastrointestinal tract of man[1] and of the rat[2]. 'Liptril' contains vitamin B_{12} as well as various other vitamins, minerals, preservatives, flavours, and colouring material. However, Greenberg[2] and Chow[1] and their associates are in agreement that the substance responsible for the increased absorption of vitamin B_{12} is D-sorbitol, present in a concentration of 28 per cent. A similar effect was also noted in rats with certain other sugars and sugar alcohols[2].

Greenberg and his associates[2] suggest that the carbohydrate portion of the intrinsic factor may be important in vitamin B_{12} absorption. In the gastrectomized rat measurement of the effect of rat intrinsic factor may conveniently be made[3] with a dose of 0·015 μgm. of vitamin B_{12} labelled with cobalt-60. On the other hand, in the studies of Greenberg and his associates[2] with D-sorbitol on normal rats a much larger dose of the labelled vitamin (1·36 or 1·4 μgm.) was employed. Likewise, Chow and his associates[1] used 50 μgm. instead of the usual 0·5–2·0 μgm. in the Schilling urinary excretion test employed by them in demonstrating the activity of D-sorbitol in man. It therefore appeared to be of interest to learn whether D-sorbitol is effective in the rat, with or without intrinsic factor, in increasing the absorption of a small dose of vitamin B_{12}. Appropriate studies were accordingly undertaken on intact rats, as well as on rats previously subjected to total gastrectomy.

The techniques of total gastrectomy, administration of test materials, and collection and assay of faeces for radioactivity were as described by Nieweg and his associates[3]. Male rats of the Sprague-Dawley strain, weighing 200–250 gm., were subjected to total gastrectomy and allowed to recover for several days from the operation. Normal male rats of similar weight and of the same strain were employed in other experiments. The test solutions were administered by stomach tube to fasting animals, stools were collected for 96 hours thereafter, and the amount of radioactivity excreted was determined and expressed as a percentage of that administered. The test solution consisted of 1 or 2 ml. of a modified, partial aqueous formulation of 'Liptril' prepared without vitamin B_{12} and containing 28 per cent by weight of D-sorbitol, together with 0·5 ml. of water containing 0·015 μgm. of labelled vitamin B_{12} with a specific activity of 565 μc. per μgm. The control solution consisted of 2 ml. of isotonic saline and 0·5 ml. of the same solution of the vitamin.

It was soon noted that diarrhœa was frequent in the normal animals receiving the 2 ml. dose of modified 'Liptril', free of vitamin B_{12} (hereafter called modified 'Liptril') and was invariable in the gastrectomized animals receiving this dose. Consequently, results obtained with animals with diarrhœa are excluded, and in the gastrectomized animals only those obtained with 1 ml. of modified 'Liptril' are reported. No attempt was made to separate the animals which had received modified 'Liptril' from those given isotonic saline as a control, and so a number of the animals received both preparations separated by an interval of at least two weeks.

As shown in Table 1, the normal rats excreted about 50 per cent, the gastrectomized rats essentially all, of the radioactivity of the dose of labelled vitamin B_{12} administered. No certain differences were noted between the average fæcal excretion of radioactivity by those animals receiving modified 'Liptril' and by those receiving saline. This lack of effect applied to both the intact rats and the gastrectomized animals.

In the technique employed here, all or nearly all the radioactivity of a dose of 0·015 μgm. of vitamin B_{12} labelled with cobalt-60 is excreted by the gastrectomized rat[3]. However, the simultaneous administration of 3 ml. of rat gastric juice or of one-half of a

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* National Research Fellow in the Medical Sciences.

Table 1. FÆCAL RADIOACTIVITY AS PERCENTAGE OF ORAL DOSE OF RADIOACTIVE VITAMIN B_{12}

Animal type	No. of experiments	Vehicle for Co^{60}–B_{12} 0·015 μgm.	Fæcal radioactivity (per cent ± 1 S.D.)
Intact rat	12	D-Sorbitol elixir*	43·7 ± 12·0
,, ,,	12	Saline	44·0 ± 6·7
Gastrectomized rat	5	Modified 'Liptril'	99·0 ± 10·4
,, ,,	10	Saline	93·6 ± 8·3

* Modified, partial, aqueous formulation of 'Liptril' prepared without vitamin B_{12} and containing 28 per cent of D-sorbitol.

homogenized rat stomach will reduce the fæcal excretion of radioactivity to approximately that of the normal rat, about 50 per cent of the dose administered. The absence of any such effect with modified 'Liptril' in these gastrectomized rats suggests that, even at the maximum dose tolerated without diarrhœa by the animals, it did not take the place of rat intrinsic factor; nor did twice this amount of modified 'Liptril' enhance the absorption of the small dose of vitamin B_{12} by the intact animal. On the other hand, 'Liptril' free of vitamin B_{12} or D-sorbitol apparently augments absorption of vitamin B_{12} by the intact rat when approximately 100 times as much vitamin is administered[2].

In pernicious anæmia Ross and his associates, and recently Doscherholmen and Hagen[4], have demonstrated that two mechanisms seem to exist for the absorption of vitamin B_{12}. Rapid absorption follows a rather large dose of the vitamin (50–3,000 μgm.) and is independent of or even inhibited by intrinsic factor. On the other hand, a slower, apparently physiological mechanism, dependent upon the presence of intrinsic factor, is required for the absorption of small amounts of vitamin B_{12} (0·5–1·0 μgm.). The substance in 'Liptril' promoting the absorption of large doses of vitamin B_{12} in the rat[2] and in man[1] has been shown to be D-sorbitol. Consequently, those reports, as well as the present experiments, suggest that D-sorbitol affects the rapid mechanism for the absorption of vitamin B_{12} in man described[4] as independent of intrinsic factor activity. Further evidence for this is found in the ability of D-sorbitol and of certain other carbohydrates to enhance iron absorption in both the rat and man[5] as well as calcium absorption in the rat[6]. Other observations in patients underline the importance of the size of the dose of vitamin B_{12} in determining the ability of D-sorbitol to enhance its assimilation. Thus, Chow and his associates failed to observe such an effect in pernicious anæmia when 2 μgm. of radioactive vitamin B_{12} were given during remission, whereas Helen E. Duell[7] has observed enhanced hæmatopoietic activity with D-sorbitol in a few such patients in relapse when the dose of vitamin B_{12} was 15 μgm.

The carbohydrates reported to be active in promoting the absorption of vitamin B_{12}, calcium, and iron in the rat seem to be those classically considered to be absorbed by passive diffusion from the intestine, whereas carbohydrates considered to be absorbed by phosphorylation, such as glucose and fructose, are reported to be inactive[2]. This perhaps further suggests that the action of D-sorbitol does not involve a specific transport mechanism.

We are indebted to Mrs. Felicita Fradera for technical assistance, to Dr. S. M. Greenberg, of Smith, Kline and French Laboratories, for D-sorbitol, and to the Merck, Sharp and Dohme Research Laboratories for the labelled vitamin B_{12}.

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DEGRADATION OF BLOOD GROUP-SPECIFIC MUCOPOLYSACCHARIDES BY FICIN AND PAPAIN

By A. PUSZTAI and PROF. W. T. J. MORGAN, F.R.S.

The Lister Institute of Preventive Medicine, London, S.W.1

MUCOPOLYSACCHARIDES composed of carbohydrate and amino-acids firmly bound together are responsible in man for immunological specificity within the ABO and Lewis blood group systems[1]. The specific substances are usually isolated by extraction of freeze-dried secretions or tissue digests with cold 90 per cent phenol solution, the serologically active mucopolysaccharide remaining largely insoluble in this solvent whereas the protein impurities pass into solution[2]. By the use of this simple procedure, followed by fractionation of the specific materials from aqueous solution by organic solvents and/or inorganic salts, it has been possible to isolate and study the properties of the human blood group substances[3]. In spite of the different serological characters of the A, B, H and Le^a substances, they each possess the same qualitative composition and contain the same four sugars—L-fucose, D-galactose, D-glucosamine and D-galactosamine, and eleven amino-acids, none of which is aromatic or contains sulphur.

Proteolytic enzymes have also been used to remove adventitious protein during the isolation and purification of the group substances from materials of human and animal origin, and it has generally been accepted that the specific mucopolysaccharides are not changed by such treatment[4]. A few early observations[5], however, suggested that in certain instances a destruction or modification of the serological character occurs, but where this has been reported the modified substances were not recovered and the physico-chemical changes induced were not determined.

A study of the literature reveals that, almost without exception, the preparation of highly purified specific mucopolysaccharides has involved at some stage treatment with 90 per cent phenol. An attempt was therefore made to isolate the specific substances by a method[6] which did not involve the use of phenol, and to achieve this the native secretions or tissues were incubated with activated ficin at about *p*H 7. It was hoped by this means to remove the accompanying unspecific protein and ultimately to recover unchanged the specific substances. Mucopolysaccharides recovered after treatment with ficin, however, gave solutions of much-reduced relative viscosity, as compared with the materials isolated by means of simple phenol extraction. The ficin-treated group substances were readily soluble in phenol and even soluble to some extent in liquid 95 per cent w/w phenol, whereas specific substances recovered by extraction of the original materials with 90 per cent phenol were largely insoluble in this solvent. The behaviour of relatively homogeneous specific substances on ultracentrifugation and electrophoresis at *p*H 4 and 8 suggested that after ficin treatment they became polydisperse and contained more than a single component. These marked differences in properties indicated that an alteration in the structure of the specific mucopolysaccharides had occurred, but no definite evidence was obtained at that time that the serological properties of the materials were modified.

A closer examination of the substances treated with ficin with those recovered from the same source by simple phenol extraction revealed that the specific substances after treatment with ficin have a lower capacity to neutralize the corresponding antibody in hæmagglutination tests. This reduced activity is not always obvious when cyst fluids or other secretions are given a single short treatment with ficin at *p*H 7, especially when they contain, as they frequently do, a large excess of unspecific protein.

These additional findings prompted a more detailed study of the action of ficin on preparations of specific substances which had been extensively purified by several successive extractions with cold 90 per cent phenol until their analytical composition remained unchanged. To remove possible minor contaminants which might remain, the substances extracted with phenol were fractionated further with ethanol and a fraction, which amounted to about 95 per cent of the whole, separating between 43 and 45 per cent ethanol concentration, was collected. Purified ficin was obtained from dried commercial fig latex by dialysis and fractionation with ammonium sulphate[7]. The material was electrophoretically homogeneous and behaved as a single substance when eluted from a column of Amberlite I*RC*–50 with $0 \cdot 2M$ phosphate buffer (*p*H 5·6). Experiments were also made with crystalline ficin.

A typical hydrolysis experiment was carried out as follows: thoroughly purified *A* substance dissolved in phosphate-citrate buffer at *p*H 4 was incubated at 37° for 16 hours with about 1 per cent w/v ficin, which had been activated with 2 : 3 dimercaptopropanol (B.A.L.). Toluene was added as a preservative. The solution was then saturated with ammonium sulphate, filtered, dialysed free from salt, evaporated under reduced pressure and dried from the frozen state. The treatment with ficin was repeated and the final product was fractionated from 2 per cent w/v solution in 2 per cent w/v sodium acetate solution, by the addition of ethanol. The major part of the substance separated between 47 and 55 per cent v/v ethanol, whereas the original material under similar conditions precipitated completely between the levels 43 and 45 per cent v/v ethanol. The substance treated with ficin was found to be closely similar in composition to the material before treatment, but possessed no more than about 3–6 per cent of the activity of the original A substance, when measured in the same test against natural human anti-A agglutinin. The value for activity showed a smaller reduction when immune rabbit or human serum was used, but the final figure attained varied somewhat according to the specimen of anti-A serum used. Materials separating at higher (50–60 and 60–75 per cent v/v) concentrations of ethanol were relatively small in amount but gave similar analytical figures, and showed an even lower serological activity. Rabbit anti-A serum and pneumococcus type XIV horse anti-serum precipitated strongly when mixed with an equal volume of a 0·1 per cent solution of all these mucopolysaccharide fractions. There was no evidence that the capacity of the materials to inhibit the hæmolysis of sheep cells by anti-A cell immune rabbit serum, and complement decreased significantly. The material remaining in solution in 75 per cent ethanol possessed about 0·2 per cent of the activity of the original A substance; nevertheless, it remained closely similar to the original substance in chemical composition. Typical analytical figures obtained for the products arising from group A substance are given in Table 1. Ficin brings about the changes described over a broad *p*H range (4–7·6). Repeated treatment with ficin of the main fraction, which was precipitated from solution between 47 and 55 per cent v/v ethanol, failed to lower further the serological activity or change the analytical composition (after the fourth treatment with ficin: nitrogen, 4·3; fucose, 24·9; hexosamine, 30·9; reducing sugar, 53·3 per cent) and material soluble in 75 per cent v/v ethanol was no longer formed. Complete serological inactivation, as measured by precipitation and hæmagglutination inhibition tests, however, can be readily brought about by the action of an enzyme preparation obtained from *Trichomonas foetus*[8].

Table 1. ANALYTICAL VALUES FOR THE PRODUCTS OF THE ACTION OF FICIN ON BLOOD GROUP A SUBSTANCE

	Original A substance	Fractions precipitated from ficin-treated A substance				
		Ethanol concentration (per cent)				
		47–50	50–55	55–60	60–75	above 75
Nitrogen (per cent)	5·2	4·4	4·7	4·4	4·4	3·4
Fucose (per cent)	23·4	25·5	23·8	23·4	21·5	17·4
Hexosamine* (per cent)	31·5	32·0	31·6	32·0	30·4	26·0
Reducing sugar* (per cent)	50·0	51·3	53·5	51·4	52·3	57·0
Hæmagglutination inhibition activity (μmoles)	0·5	8	8	16	64	128
Specific optical rotation $[\alpha]_D$	− 50°	−30°	−43°	−42°	−46°	—
Relative viscosity at 20° in water (1 per cent solution)	4·68	2·39	1·51	1·21	1·10	—

* After the materials have been hydrolysed with 0·5 *N* hydrochloric acid for 18 hr. at 100°. Hexosamine is given as 'base'; the reducing values in terms of glucose equivalents.

Similar experiments, in which the step involving purification with ammonium sulphate was omitted and the dialysis waters were concentrated and examined by chromatography for diffusible products, showed that simple sugars and oligosaccharides were not released in demonstrable amounts from the specific substances as a result of treatment with ficin. Amino-acids and/or peptides were usually found in the diffusates, but only in small quantities. Their appearance can be correlated with the small but consistent decrease in the nitrogen content of the material recovered after treatment with ficin, but it has not yet been finally established whether these amino-acids are derived from the specific mucopolysaccharide alone, and the loss in specific activity is due to changes induced by their release, or whether they arise from small amounts of contaminating protein or peptide in the specific substance.

Similar detailed hydrolysis experiments with ficin have been made using H substance, and its general behaviour cannot be distinguished from that described above for A substance (see Table 1). Although as yet studied in much less detail, B and Le^a substances appear to be changed by ficin in a similar manner, again with extensive but limited loss in serological activity.

The specific mucopolysaccharides have been treated with crystalline papain under similar conditions, and here again the same sequence of events has been found to occur; there was a reduction in serological activity to a value equivalent to a few per cent only of the original, and no very obvious change in chemical composition occurred. The results of some preliminary experiments indicate that papain can extend the hydrolysis brought about by ficin, which suggests that these two proteolytic enzymes can act on different peptide structures within the mucopolysaccharides.

The changes observed when ficin acts on the specific substances can be explained most simply by assuming that the materials, which are macromolecular carbohydrate/amino-acid complexes, are degraded by rupture of a limited number of peptide bonds and relatively large carbohydrate/amino-acid units are set free with no release of simple sugars or diffusible oligosaccharides. In support of this suggested mode of attack, there is other evidence which can be briefly mentioned. The extent of the changes induced in the specific mucopolysaccharide depends on the quantity of the enzyme used; definite hydrolysis can still be recognized when a substrate:ficin ratio of 1,000 : 1 is employed. The hydrolysis of the specific substances can be completely inhibited if the ficin is incubated with an equimolar quantity of *para*chloromercuribenzoate before the addition of the substrate and the activity can be restored either by adding a 6–10-fold excess of substances containing free SH groups (B.A.L., cysteine, etc.), or by dialysis of the mercury-ficin compound against 0·01 *M* cystein solution. The ficin used did not contain lysozyme, and crystalline lysozyme had no action on the specific substances as measured by the hæmagglutination inhibition test. The enzyme used did not appear to contain α- or β-galactosidases or β-N-acetylglucosaminidase.

Paramucin, mucus surface epithelium, and other water-insoluble complexes containing mucopolysaccharide can be readily brought into solution by digestion with ficin or papain at neutral *p*H, and this procedure was recently suggested as the basis of a method for obtaining the specific substances from these and other biological materials[6]. Now that it has been shown that ficin and papain bring about limited, but nevertheless important, changes in the specific materials, it is obvious that these enzymes should not be used for the isolation of the specific substances, if native mucopolysaccharide preparations are required.

If the present views concerning the structures associated with blood group specificity within the ABO and Lewis systems are correct, then it is the non-reducing end residues of certain oligosaccharide units which are mainly responsible for the serological character on which group specificity depends. As a result of thorough treatment with ficin there has been no loss from the specific substances of carbohydrate, either in the form of simple sugars or as diffusible oligosaccharide fragments, and therefore presumably the specifically reactive structures are still intact in spite of the considerable fall in inhibition titre observed. It is not surprising, therefore, to find that the major part of the materials formed as a result of the limited proteolysis react strongly in specific anti-A precipitation tests.

It is clear that the chemical changes induced in the specific substances by ficin or papain are very different from those brought about by extracts of *Trichomonas foetus*[8], many bacterial culture filtrates[9], and hepato-pancreas preparations from certain snail species[10], etc., where crude or purified enzyme systems bring about an extensive release of small diffusible sugar units together with complete destruction of the characteristic serological specificity. Treatment of the specific substances with ficin and papain, on the other hand, appears to hydrolyse only a few of the potentially susceptible peptide bonds and to give rise to a limited number of smaller fragments resistant to ficin, closely similar in composition to that of the original substance, and in this manner induce changes not brought about by any method previously described. The use of these proteolytic enzymes of plant origin and possibly of other similar ones from animal tissues opens up new possibilities for an experimental approach to the isolation of relatively small structural entities containing unchanged carbohydrate units joined to peptides and ultimately, perhaps, devoid of amino-acids, and thus constitutes a valuable tool for the study of mucopolysaccharide structure.

Full details of these experiments will be given elsewhere.

This investigation was aided by a grant from the Nuffield Foundation. One of us (A. P.) wishes to thank the Ford Foundation for a studentship.

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LETTERS TO THE EDITORS

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Seasonal Illumination of a Circumpolar Earth Satellite at its Extreme-Latitude Orbit Point

Optical tracking of Earth satellites is the only means of determining their motion with such precision as to render measurements of air density significant. This, however, can only be done when the satellite is sunlit, considering that a flashing beacon (which has been suggested) would relatively quickly run out of power. I shall discuss the insolation of Earth satellites revolving on orbits similar to those of the Russian *Sputnik*.

The summit points of the orbit or points nearest the pole define a locus, *L*, which is centred on the Earth's axis, provided that the inclination of the orbit is different from zero. Verticals passing through the summit-points and their sub-points define a conical surface with its vertex at the centre of the Earth. This locus *L* (Fig. 1) forms the base of the cone, the intersection of which, with the illumination cylinder *I.Cy*, defines the illuminated arc *abc* and its complementary arc *ac*, which is in shadow. Let the angles of these arcs be, respectively, $2(\pi - K)$ and $2K$

Consider an orbit with inclination, $i = 65°$, and a height of passage at the summit-point, $h = 400$ km. (this is, somewhat schematized, the case of the Russian Earth satellites). Then we may derive *K* from the following relations and quantities (Fig. 1c):

$$\cos K = \frac{\cos \nu - \cos \varphi \cos \mu}{\sin \varphi \sin \mu}$$

where $\mu = (90° - i) = 25°$ and, if *P* is the polar distance of the Sun, $\varphi = (180° - P)$. The angle ν is given by:

$$(R + h) \sin \nu = R$$

where *R* is the radius of the Earth (6,350 km.) and *h* is 400 km. Thus:

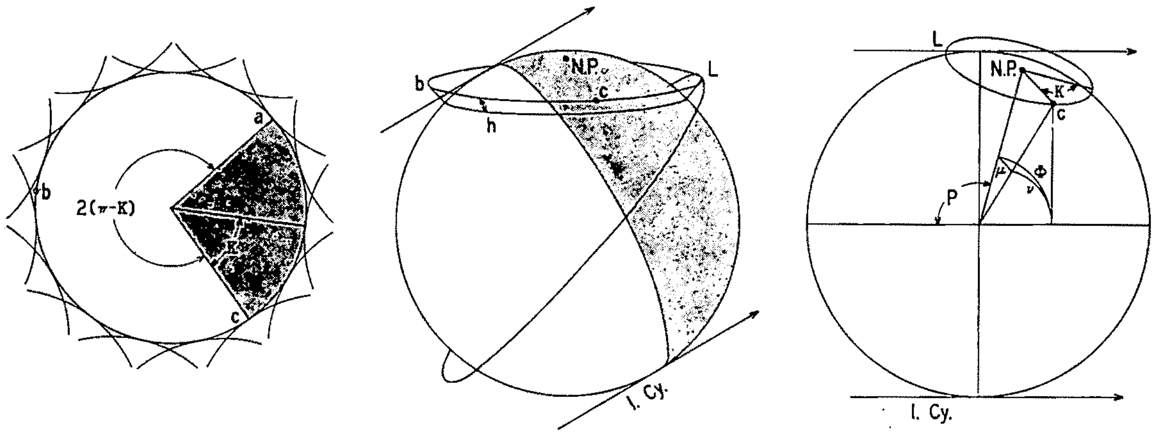
$$\cos K = \frac{0 \cdot 33901 + \cos P \times 0 \cdot 90631}{\sin P \times 0 \cdot 42262}$$

Table 1

P		*K*		$2(\pi - K)$	
Deg.	min.	Deg.	min.	Deg.	min.
084	50.0	000	00.0	360	00.0
090	00.0	036	39.5	286	40.0
100	00.0	064	07.5	231	45.0
110	00.0	085	48.7	188	22.6
113	26.5	093	10.0	173	40.0
120	00.0	108	10.7	143	38.6
125	00.0	121	31.2	116	57.6
134	49.0	360	00.0	000	00.0

Arcs $ab = 2K$ and $abc = 2(\pi - K)$ are functions of the polar distance of the Sun. Table 1 gives the values of these arcs corresponding to certain values of *P*.

These values are plotted in Fig. 2. The inner scale of the abscissæ gives the arc $2(\pi - K)$, and the outer scale gives the hours, *H*, before and after solar noon at which the summit-point would still receive the Sun's rays. When the satellite goes over that northernmost point of the orbit (for the northern hemisphere), it will catch the Sun's rays even if the rest of the orbit is in shadow. Actually, due to the refraction, the illuminated part of the orbit will be more than a point. For the northern hemisphere the summit-point of the orbit will be in constant sunlight during April 5–September 8. For the southern hemisphere these dates will be October 8–March 6.



(*a*) (*b*) (*c*)

Fig. 1

These values of *P* change considerably with the height, *h*, at the summit-point.

The *h*-curves of Fig. 2 give the values of $2(\pi - K)$ and the hours of insolation of the summit-point as a

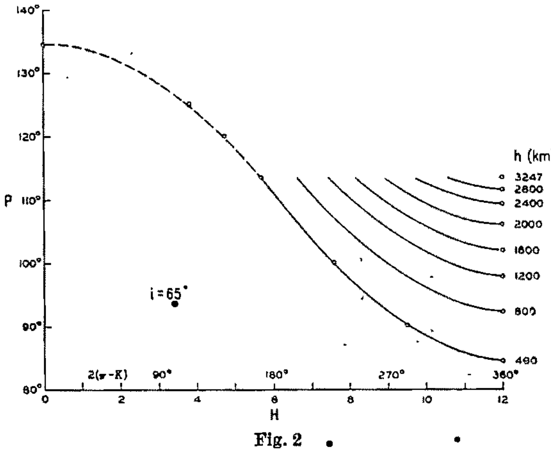


Fig. 2

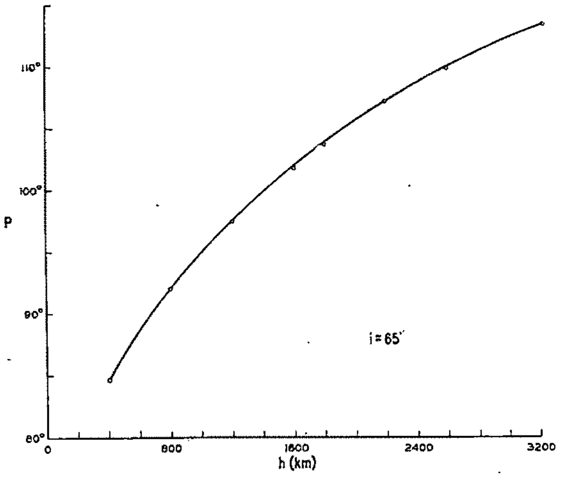


Fig. 3

function of the polar distance of the Sun, P. Table 2 gives the values of P required to give constant insolation throughout 24 hr. as a function of h.

Table 2

h (km.)	cos $(90 - \nu)$	$(90 - \nu)$ Deg.	$(90 - \nu)$ min.	P Deg.	P min.
400	0·94074	019	49.0	084	49.0
800	0·88811	027	21.5	092	21.5
1,200	0·84106	032	45.0	097	45.0
1,600	0·79784	036	59.5	101	59.5
1,800	0·77914	038	49·0	103	49.0
2,200	0·74269	042	02.3	107	02.3
2,600	0·70950	044	48.5	109	48.5
3,247	0·66327	048	27·5	113	27.0

These values are plotted in Fig. 3. All-year-round insolation of summit-point and therefore of the entire locus L will occur if the height of the satellite at the summit-point is 3,247 km., since for this value $P = 113°\ 27'$, which is the polar distance of the Sun at the winter solstice for either hemisphere. Atmospheric refraction, which will increase the illuminated arc, has not been taken into consideration.

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Interface Couples in Crystals

Joel and Wooster[1] have discussed cases in which 'volume couples' can arise in certain classes of crystals due to strains, and have mentioned that in such cases the stress tensor is not symmetrical ($\sigma_{yz} \neq \sigma_{zy}$). Actually, it is possible for asymmetry of the stress tensor to arise in any class of crystals, due to distributed couples which are acting across an interface rather than being distributed throughout a volume. These distributed interface couples have the same relation to the distributed volume couples that stresses have to distributed body forces.

Let χ_{yz} represent the component of the interface couple per unit area acting on a y-face and having its moment vector in the z-direction. For equilibrium across an interface, $\chi_{yz} = \chi_{-y-z}$. In the presence of these surface couples the moment equilibrium of a differential element can be found as noted in Fig. 1. Neglecting the effect of any volume couples for brevity, the condition for equilibrium of moments about the z-axis is:

$$\left(\sigma_{xy} - \sigma_{yx} + \frac{\partial\chi_{xz}}{\partial x} + \frac{\partial\chi_{yz}}{\partial y} + \frac{\partial\chi_{zz}}{\partial z}\right) \mathrm{d}x\, \mathrm{d}y\, \mathrm{d}z = 0 \quad (1)$$

Equilibrium of the other components of moments gives similar equations. Thus the deviation from the classical theory of elasticity in this case is due to the derivatives of the interface couples. It should be noted that the moments due to stress gradients of the type $\partial\sigma_{xx}/\partial y$ are higher-order differentials.

The transformation law for the interface couples may be derived in a manner similar to that for stresses, by considering moment equilibrium of a tetrahedron. In terms of the direction cosines $l_{ij'}$ between the i- and j'-axes,

$$\chi_{i'j'} = \sum_{i=1}^{3} \sum_{j=1}^{3} \chi_{ij} l_{ii'} l_{jj'} \quad (2)$$

Thus the interface couples are tensors. It should be noted that the stresses do not become involved in the transformation law. The interface tensor is not in general symmetrical (that is, $\chi_{yz} \neq \chi_{zy}$), so that even in two dimensions the Mohr's circle transformation would not be applicable.

It seems likely that the 'strains' resulting from these interface couples are the lattice curvatures $\varkappa_{ij}$ discussed by Bilby, Bullough and Smith[2]. Relations between the interface couples and the curvatures would add 45 elastic constants. Interaction between the usual stresses and strains and the newer concepts of interface couples and curvatures, which would occur in the case of crystals of the symmetry discussed by Joel and Wooster, would bring the total number of elastic constants to $(18^2 + 18)/2$, or 171.

An order-of-magnitude estimate of the importance of interface couples in a crystal may be obtained by assuming that the atomic forces causing interface couples are of the same order as those causing ordinary stresses. The interface couple χ acting on one face of a unit cell of dimension a gives rise to a couple χa^2. The moment arm of this couple is no greater than the order of the lattice spacing a, so that $\chi a^2/a \leqslant 0\ (F)$. But the interatomic forces are also of the order of the normal stress, $E\varepsilon$, times the area

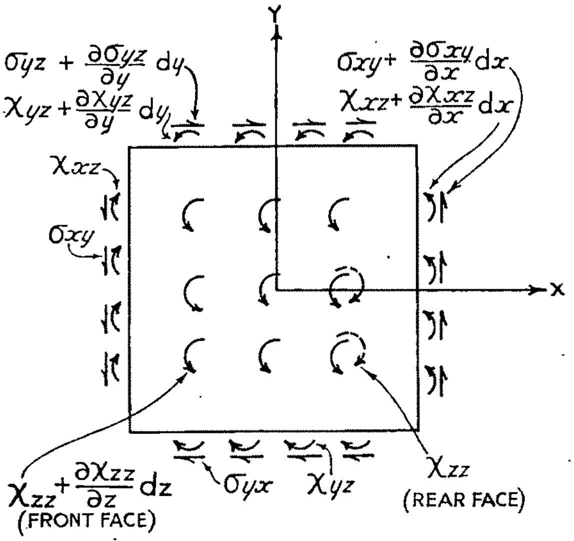
Y
X
$\sigma_{yz} + \frac{\partial\sigma_{yz}}{\partial y}dy$
$\chi_{yz} + \frac{\partial\chi_{yz}}{\partial y}dy$
$\sigma_{xy} + \frac{\partial\sigma_{xy}}{\partial x}dx$
$\chi_{xz} + \frac{\partial\chi_{xz}}{\partial x}dx$
χ_{xz}
σ_{xy}
$\chi_{zz} + \frac{\partial\chi_{zz}}{\partial z}dz$
(FRONT FACE)
σ_{yx}
χ_{yz}
χ_{zz}
(REAR FACE)

Fig. 1

of the face: $F = 0\ (E\varepsilon a^2)$. Thus the interface couples will be no greater than $\chi \leqslant 0\ (E\varepsilon a)$. For the gradients of the couples to be of the same order as the shear stresses, so that, from equation 1, $\sigma_{xy} - \sigma_{yx} = 0\ (\sigma_{xy}) = 0\ (\sigma_{xx})$, the difference of the shear stresses is of the magnitude of the stresses themselves:

$$\frac{\partial \chi}{\partial x} = 0\left(Ea\,\frac{\partial \varepsilon}{\partial x}\right) = 0\ (E\varepsilon)$$

$$\text{or}\quad \frac{\partial \varepsilon}{\partial x} = 0\left(\frac{\varepsilon}{a}\right)$$

Such high gradients of strain would be expected only around singularities such as cracks and dislocations.

Interface couples may also be of importance in laminated plastics reinforced by fibre. If alternate plies are laid with the fibres perpendicular to each other, and the whole assembly pulled at 45° to both fibre directions, there will be couples acting on the interfaces between plies wherever fibres cross over each other. The sign of these interface couples changes from one side of a ply to the other, so that there would be large gradients of the interface couples and hence $\sigma_{xy} \neq \sigma_{yx}$.

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Molecular Orbitals and Vibrational Potential Function of Nitryl Fluoride

In their work on the electronic structure of the N_2O_4 molecule, in which the N—N bond was found to be a π-only bond, Coulson and Duchesne[1] were led to consider the structure of a single NO_2 molecule. This can be represented using in particular two nitrogen lone-pair electrons, three π-electrons associated with the whole O—N—O framework and four σ-electrons. The aim of this communication is to see to what extent this picture may be used as a basis for the study of NO_2F in terms of molecular orbitals. In this molecule, contrary to what occurs in N_2O_4, N_2O_3 and N_2O_2, we should expect a normal σ-bond for NF. Such a bond should be obtained by promoting one of the lone-pair electrons to the π-orbital labelled Q by Coulson and Duchesne[1]. This gives rise to a total of four π-electrons, distributed in the P and Q molecular orbitals, whereas the remaining lone-pair σ-electron is coupled with the $2p_z$ electron of fluorine.

Let us now consider the effects which can be expected from this redistribution of electrons on the properties of the NO_2 group. As the Q orbital may be assumed to be $O \leftrightarrow O$ anti-bonding, the ONO angle has to be larger in NO_2F than in NO_2, whereas the corresponding bending force constant should be smaller. On the other hand, as the Q orbital is $N \leftrightarrow O$ non-bonding (or perhaps very slightly anti-bonding), the change in the NO bond-lengths ought to be insignificant, though the variation of the hybridization character at the nitrogen atom caused by the angle opening might give rise to a small bond shortening.

Table 1

Force constants	NO_2F	NO_2*	NF_3†
f_{NF}	4·3– 5·3		4·28–5·27
f_{NO}	11·0–11·8	10·42	
f_{ONO}	0·2– 0·5	1·099	
f_{FNO}	1·5– 1·6		

* From ref. 5.
† From values given in ref. 6.

The validity of this model must be tested, and a comparison with the vibrational potential function is valuable. (It is to be noted that the molecular dimensions reported[2] for NO_2F are affected by the fact that the value for the ONO angle had to be assumed.)

In Table 1 are given the limits between which the force constants of NO_2F (expressed in 10^5 dynes/cm.), which is of C_{2v} symmetry[2,4], are found to vary when making reasonable assumptions of the values of the coupling constants. (The accuracy for the values of the interaction terms is too low to make any suggestion here. It is, however, fairly certain that $f_c(NO/NF)$ and $\gamma_c(NF/ONO)$ are respectively positive and negative.) The results have been deduced from a general potential function, introduced earlier by Duchesne[3]. The infra-red and Raman data have been taken from the work of Dodd, Rolfe and Woodward[4]. For comparison, the corresponding constants for NO_2 and NF_3 are also given in the table.

First, it is seen that the NF stretching constants are almost the same in NO_2F and NF_3, in agreement with our model. Secondly, on going from NO_2 to NO_2F a large weakening of the bending constant (about 65 per cent) and a small strengthening of the NO bonds (about 10 per cent) are observed. This also was to be expected on the basis of the general properties of the Q orbital, the anti-bonding character of which is now estimated. The extension of these results to the discussions of molecules such as NO_2Cl and NO_2Br is premature, due to lack of experimental data. It is to be hoped that the present work, which may be compared with Duchesne's work on the electronically excited molecules[3], may indicate a fruitful way for testing and evaluating the properties of the molecular orbitals.

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An Oxidation Reaction Highly Dependent on Pressure

The rates of oxidation of metals in gases at high temperatures are frequently influenced by the pressure of the gas. The dependence on pressure, which has in some cases been theoretically explained[1], is generally small, often according to some fractional power[2]. During an investigation of the oxidation of aluminium alloys in high-temperature steam we have found a very much greater dependence on pressure.

In our experiments, the alloy "Aereal 1" (aluminium + 2·5 wt. per cent nickel), chosen for study because of its good resistance to high-temperature water[3], was exposed to dry steam at 325° C. and pressures from 550 to 1,500 lb./in.^{2} for periods up to 160 hr. Oxidation was assessed by the gain in weight of the specimen—a valid measure, since wholly adherent films were formed. Oxidation/time curves for each pressure followed a parabolic equation ($w = Kt^m$), where $m = 0{\cdot}48$. The constant K was found to be markedly dependent on pressure; assuming $K \propto p^n$, values of n from 3·9 to 4·3 were obtained, so that the parabolic rate constant was approximately proportional to the fourth power of the pressure.

Since the reaction followed a parabolic relation with time at all pressures, implying that the rates are inversely proportional to film thickness, the controlling process must be diffusion through the oxide film. It is on the latter, therefore, rather than on a surface reaction of the oxide/steam interface, that variations of steam pressure must exert their effect. No certain explanation of the effect can be offered at present, but it seems likely that, under the conditions of the experiments, the composition of the film is significantly changed by variations of steam pressure.

Studies of the equilibrium between steam and bulk aluminium oxides indicate that corundum (α-Al_2O_3) replaces böhmite (γ-$AlO(OH)$) as the stable phase at about 385° C. [4]. This transition temperature may be rather lower when the oxide forms as a surface film, as is true of the analogous change from bayerite ($Al(OH)_3$) to böhmite. (For the bulk substances, the transition temperature[5] is 130° C.; but, on corroding aluminium, böhmite forms the film[6] above 60° C.). The conversion of $AlO(OH)$ to Al_2O_3 involves the elimination of water, so that at lower pressures the film composition should be nearer α-Al_2O_3, which might well be more protective than böhmite. If the experimental temperatures were near that of the transition at the pressures studied, a large dependence of composition, and thus of corrosion-rate on pressure, could occur. Preliminary results at 350° C. (and similar steam pressures) suggested not only that rates of corrosion were lower than at 325° C., indicating a more protective film, but also that the dependence on pressure was less, as might be expected further from the transition temperature.

Additional experiments, including a study of the composition of the oxide films, are proceeding and will be reported elsewhere.

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Thermal Decomposition of Hydrogen Peroxide Vapour

KNOWLEDGE of the decomposition of hydrogen peroxide vapour is of considerable importance to the developing understanding of unimolecular reactions and also of the oxidation of many gaseous fuels. McLane[1] and Giguère and Liu[2] claimed the overall homogeneous decomposition to be first-order. Satterfield and Stein[3] claimed that the decomposition occurred by a chain reaction the overall order of which was 1·5. We have carried out an extensive investigation of the decomposition and shown that it is non-chain and second-order (that is, the rate can be expressed as $k[H_2O_2]\,[M]$) up to pressures of at least 1 atmosphere of nitrogen). We have further shown that the first step in the decomposition must be the second-order reaction:

$$H_2O_2 + M \rightarrow 2OH + M \qquad (1)$$

Hoare and Walsh[4] had earlier given reasons why (1) would be expected to be second-order at ordinary pressures. The efficiency of M in bringing about reaction (1) decreases in the order $H_2O_2 > H_2O > CO_2 > N_2 > O_2 > He$.

Using our values for the efficiencies of the gases which played the part of M in the work of McLane[1], Giguère and Liu[2] and Satterfield and Stein[3], we have calculated, from the results of these authors, second-order rate constants which, after proper correction for heterogeneous effects, agree excellently one with another and with our own results. The rate constant of (1), when M is H_2O_2, is found to be $10^{15{\cdot}4} \exp(-48{,}000/RT)$ l.mole^{-1} sec.$^{-1}$.

A full account of this work will be published elsewhere.

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Deuterium Exchange in Polypeptides

OBSERVATIONS on the rate of deuteration of the NH groups in solutions of proteins in heavy water (see, for example, ref. 1) have shown that in some proteins there is both a fast and a slow exchange, and it has been conjectured that those NH groups which exchange slowly are hydrogen-bonded in α-helix arrangements, whereas the fast reaction is associated with solvated NH groups. This possibility can be more profitably examined in solutions of a simple polypeptide such as poly-γ-benzyl-L-glutamate, where the conditions for α-helical or random, solvated coil forms are now well-known[2,3]. Doty and Yang[3] have shown that in mixtures of dichloracetic acid and ethylene dichloride, samples of poly-γ-benzyl-L-glutamate of high molecular weight may exist either in α-helix or in random coil forms, according to the composition of the solvent.

We have followed the rate of deuterium exchange by measuring the strength of the hydrogen-bonded peptide NH band at about 3,300 cm.$^{-1}$. Since chloroform is more transparent in this region than ethylene dichloride, we have used a mixture of chloroform and O-deuterated dichloracetic acid as solvent. By measurement of the dispersion of optical rotation, we have found, as expected from the work of Doty and Yang, that with 10 per cent dichloracetic acid in chloroform (v/v) the polymer is all in the α-helix form. In pure dichloracetic acid only the random form is found[4].

If poly-γ-benzyl-L-glutamate is dissolved in O-deuterated dichloracetic acid, and chloroform is added to give a 10 per cent solution of the acid, the spectrum of the solution is found to show no NH band, even when the time required for solution and observation is reduced to less than an hour. The deuterium exchange evidently proceeds very rapidly. When, on the other hand, the polymer is first dissolved in chloroform, and 10 per cent of O-deuterated dichloracetic acid is then added, a strong NH band is seen in the spectrum; this band does not diminish appreciably in a period of days, and deuterium exchange is very slow. There is therefore no doubt that, under the conditions described with a polymer concentration of 0·5 per cent w/v, the random, solvated coil allows the deuterium exchange to proceed very much more quickly than the α-helix form. It would, however, be rash to suppose that there are not other important factors to be considered in interpreting deuterium exchange in protein solutions.

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Quantitative Separation of Nitrogenous Organic Bases using Ammonium Reineckate

DURING a study of the reineckates of a series of clinically important basic compounds, the mechanism of the reaction between the bases and ammonium reineckate was studied. It was found that the formation of the complexes depends on the basicity of the compounds, and that under suitable pH conditions certain bases can be separated quantitatively from one another. A brief discussion of the reaction mechanism on which the separation is based is presented here, and a full report on this work will be published elsewhere.

When a base (B) is dissolved in water the following equilibrium exists:

$$B + H_2O \rightleftharpoons BH^+ + OH^- \qquad (1)$$

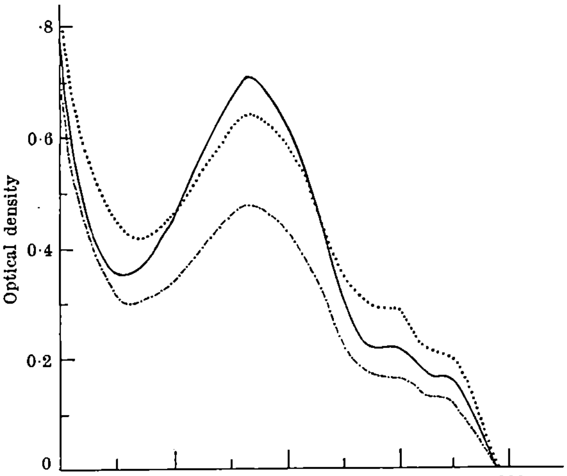

Fig. 1. Spectra of strychnine. ———, The standard strychnine, 2 mgm./100 ml.; –·–·–, from liver; ......, from liver with caffeine added. Solvent, 95 per cent ethyl alcohol

With the addition of an ammonium reineckate solution the conjugate acid, BH^+, thus formed will react with the $[Cr(NH_3)_2(SCN)_4]^-$ ions arising out of the dissociation of ammonium reineckate and form the relatively insoluble reineckate complex, thus:

$$BH^+ + [Cr(NH_3)_2(SCN)_4]^- \rightarrow BH[Cr(NH_3)_2(SCN)_4] \qquad (2)$$

The equilibrium represented by equation (1) is disturbed and more conjugate acid will be formed to replace the reineckate salt as it is removed. It is obvious that in an aqueous solution the formation of the reineckate complex depends on the formation of the conjugate acid BH^- from the base B.

The equilibrium between the conjugate acid and water is:

$$BH^+ + H_2O \rightleftharpoons H_3O^+ + B \qquad (3)$$

The extent to which this equilibrium will exist will depend not only on the strengths of the bases but also on the pH of the reaction media. The relation between these variables may be expressed by an equation of the form

$$\log \frac{[B]}{[BH^+]} = pH + pK_b - 14 \qquad (4)$$

where pK_b is the dissociation constant of the base.

In practice, the pK_b values of the bases can be obtained, and by using equation (4) the required pH of the reaction media can be calculated; this will either be favourable or unfavourable for the formation of a particular reineckate. Thus piperidine (pK_b 2·8) and pyridine (pK_b 8·6) can be separated in an ammonical solution of ammonium reineckate at pH 9. After the separation of the piperidine reineckate, acidification of the filtrate to pH 2 aids the formation of pyridine reineckate.

In cases where the compounds are not very soluble in an aqueous solution the reaction may be carried out by dissolving the bases in chloroform or benzene and shaking it with an aqueous solution of ammonium reineckate of the required pH. The separation of codeine (pK_b 6·05) and caffeine (pK_b 13) at pH 7 was effected in this way. Tables 1 and 2 show recoveries of piperidine and pyridine, and codeine and caffeine, respectively, from mixtures.

Table 1. Recovery of Piperidine and Pyridine from Mixture

Piperidine used (mgm.)	Pyridine used (mgm.)	Piperidine recovered (mgm.)	Pyridine recovered (mgm.)
83·0	147·3	82·6	145·0
150·8	38·7	151·2	37·3

Table 2. Recovery of Codeine and Caffeine from Mixtures

Codeine used (mgm.)	Caffeine used (mgm.)	Codeine recovered (mgm.)	Caffeine recovered (mgm.)
52·4	256·3	51·4	252·7
15·7	482·4	15·2	477·5

The separation of basic putrified materials (mainly ptomaines) from basic nitrogenous poisons from highly decomposed human liver has been effected by precipitation of the interfering substances in ammoniacal solution of pH 9. The purity of the recovered strychnine from highly putrified human livers using this procedure is demonstrated in Fig. 1.

A dibasic substance may be treated as a mixture of two bases since it possesses two different dissociation constants. In agreement with the reaction mechanism just discussed many of the dibasic antihistamines studied gave the di-reineckate derivatives in acid solution (pH 2); in water (pH 7) only the mono-reineckates are obtained. Equation (4) also shows that the reineckates of very weak bases can only be formed in strongly acidic media. Urea, which is reported as not forming a reineckate[1], has yielded a reineckate under these conditions.

Thus, with a knowledge of the reaction mechanism, ammonium reineckate has become a very versatile and useful reagent. It can be used for the separation of certain mixtures of bases besides forming derivatives with them which are useful for identification and determination. Molecular weights of the conjugate bases can be obtained by spectrophotometric analysis of the complexes. The free bases can also be regenerated easily by using ion-exchange resins.

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Swift Dumas Nitrogen Estimation

A novel apparatus, Fig. 1, has been designed which enables the rapid estimation of nitrogen by the principle of Dumas and Pregl[1].

The apparatus (patent applied for by Loughborough Glass Co., Ltd., Loughborough) comprises two concentric combustion tubes C_1 and C_2. The centre tube C_1 has a side-arm A passing through the outer tube C_2. C_2, having twice the diameter of C_1, is sealed at one end, and has a B.S. cone $C19$ at the other end.

When initially setting up the apparatus, a copper gauze plug N is inserted into the far end of tube C_1, followed by a layer of fine copper oxide wire CuO, 15 mm. long, which is kept in place by an asbestos plug P_1. Tube C_1 is stoppered with a rubber bung R_s, and the annular space between the tubes is packed with fine copper oxide for 50 mm., followed by a 30 mm. filling of copper wire and finally copper oxide wire within a distance of 50 mm. from cone $C19$. The filling of tube C_2 is kept in place by asbestos plug P_2. Side-arm A is connected to a carbon dioxide generator using a rubber tube R_T and a screw clip T_1. An asbestos sheet X is arranged over the combustion tube as in Fig. 1, and, with carbon dioxide passing through, the tubes are heated and left to cool.

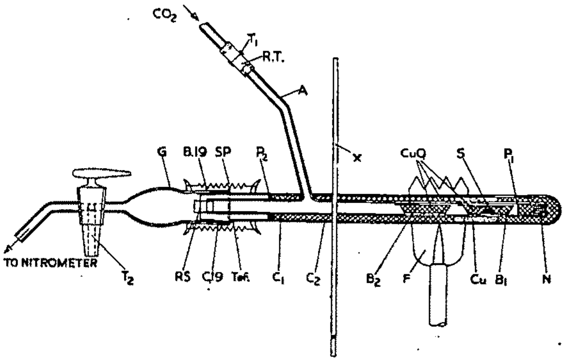

Fig. 1

Through G, which consists of a $C19$ socket and a three-way tap T_2, the apparatus is connected to the nitrometer. The cone and socket joint is sealed with a 'Teflon' sleeve *Tef*, the connexion being secured with springs.

For analysis, a sample of 3–7 mgm. is weighed into a suitable container, which is then placed in a metal boat B_1 and covered with copper oxide. With tap T_1 open, bung R_s is removed and boat B_1 is placed in the far end of tube C_1. A second boat B_2 filled with copper oxide is placed in front of it. Bung R_s is replaced and cone $C19$ with the 'Teflon' sleeve attached to it, connected to socket $C19$.

With tap T_1 open and tap T_2 open to the atmosphere, carbon dioxide is bubbled through for about 1 min. Tap T_2 is then opened to the nitrometer. As soon as micro-bubbles are obtained and the froth is taken off in the nitrometer, the combustion can be started.

Tap T_1 is closed and tap T_2 opened. Flame F is placed under the part of the tube containing the copper layer and slowly moved towards the end of the tube. Combustion is complete after about 5 min., when escape of bubbles into the nitrometer will stop. Tap T_2 is then closed and tap T_1 opened. T_2 is then adjusted so that bubbles escaping into the nitrometer follow each other closely. The flame is removed and the tube left to cool. After about 5 min. carbon dioxide micro-bubbles will appear again in the nitrometer. Tap T_2 is connected to the atmosphere and after the usual period the volume of nitrogen is read.

Results obtained using the procedure described are given in Table 1. More details will be published later.

Table 1

	Sample (mgm.)	Percentage nitrogen (theory)	Percentage nitrogen (found)
Dinitrobenzene	4·546	16·67	16·60
	4·778		16·63
	4·694		16·71
	5·251		16·62
Azobenzene	5·060	15·37	15·30
	4·664		15·38
	3·512		15·47
	6·578		15·34

My thanks are due to Miss Y. Law and Mrs. V. Taylor for most efficient assistance; to Mr. Evans for skilful work in making this apparatus; to Mr. Lambie for encouragement throughout and to the Directors of Fisons Pest Control, Limited, for permission to publish this communication.

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A Minor Anthocyanin Pigment of Sweet Cherry

THE sweet cherry contains an anthocyanin, keracyanin, the rhamnoglucoside of cyanidin, which was first isolated by Willstätter and Zollinger[1]. Robinson and Robinson[2] indicated the presence of a cyanidin-3-monoside in the skins of small black cherries. The complete picture of the anthocyanin pigments of any one species of sweet cherry, however, has not been reported.

Recently a method of isolation of the natural anthocyanins involving silicic acid chromatography has been developed in this laboratory, and proved useful in pigment studies in sour cherries[3] and the wild strawberry[4]. The present work was undertaken to extend this method to the case of sweet cherries[5].

The crude anthocyanin pigments of sweet cherries (*Prunus avium* L., var. Windsor) were prepared by the procedure previously described for sour cherries[3]. Two pigment components of the crude anthocyanin mixture were separated from the silicic acid column, employing the upper phase of the solvent system, *n*-butanol/acetic acid/water/benzene (4 : 1 : 5 : 2 v/v) for developing and elution.

The major anthocyanin pigment, which separated as the upper band on the silicic acid column, comprised about 85 per cent of the total pigments, as compared with the 15 per cent for the minor pigment, which constituted the lower band. These proportions of the two anthocyanins were the same both in the skin and in the highly coloured flesh of the sweet cherry.

The major anthocyanin pigments, after being eluted from the silicic acid column, were crystallized from methyl alcohol containing 2 per cent hydrochloric acid in the characteristic brown-orange needle clusters of antirrhinin as isolated from sour cherries[3]. This major fraction was shown to be cyanidin-rhamnoglucoside or keracyanin by the same procedure as used for the identification of the antirrhinin from sour cherries[3].

The minor fraction of pigment was obtained as tiny red spherical crystals after elution from the silicic acid column and crystallization from methyl alcohol containing 2 per cent hydrochloric acid. On paper chromatograms this minor pigment has R_F values identical with a synthetic sample of chrysanthemin, cyanidin glucoside, in several solvents, but these numerical values were only very slightly greater than those of synthetic idaein, cyanidin galactoside, which was also used as a control. Both the minor pigment and the chrysanthemin showed identical absorption curves with maxima at 515 and 280 mμ in 0·5 per cent hydrochloric acid solutions. In 60 per cent ethanol containing 0·1 per cent hydrochloric acid, both the major and minor anthocyanin pigments of the sweet cherry showed the same maximum absorption at 535, 333 and 282 mμ.

The crystalline anthocyanidin from acid hydrolysis of the minor pigment was identified as cyanidin by the tests previously employed for the cyanidin obtained from sour cherries[3]. From the sugar solution after hydrolysis, an osazone was prepared with phenylhydrazine, with crystalline forms of glucosazone, m.p. 205° alone or admixed with authentic glucosazone. That this sugar moiety was glucose was confirmed on paper chromatograms using several of the solvent systems of Jermyn and Isherwood[6], and found to have the same R_F values as authentic glucose. Galactose, fructose, and mannose were included as controls. The minor anthocyanin pigment of the sweet cherry is therefore chrysanthemin.

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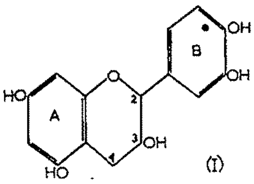
Leuco-Anthocyanins as the Possible Precursors of Tannins

ROUX has recently reported[1] that he had found leuco-anthocyanins in wattle extract and discussed biochemical aspects of these substances. The occurrence of leuco-anthocyanins in wattle and certain other tannin extracts was first referred to by Hillis in 1954[2] and further discussed by him in 1956[3]. At the same time the suggestion was put forward that leuco-anthocyanins could be the precursors of certain tannins[3,4]. Other workers also have confirmed the presence of leuco-anthocyanins in tannin extracts, and in particular in wattle extract (ref. 5 and King, H. G. C., and White, T., personal communication, May 1956).

Freudenberg[6] and others have suggested that condensed tannins are polymerized catechin (catechin I). Hathway and Seakins[7] have obtained evidence to support the view that a catechin polymer formed at *p*H 4–8 has linkages as in II. They have shown the similarity of this structure to those of the tannins from *Acacia catechu* and *Uncaria gambir*.



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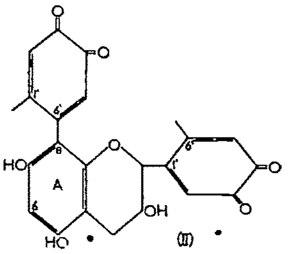

(II)

The leuco-anthocyanins which have been characterized possess a 3,4-flavandiol structure, and a polymerization similar to that of catechin would be expected to take place. However, it is difficult to reconcile the ease with which anthocyanidins are obtained from polymerized leuco-anthocyanins with such a structure.

A study of the amount and type of linkages in tannins has shown that those in a catechin polymer differ from those in certain tannins, and that those in the latter differ between themselves.

The method of examination involved the determination of the amount of formaldehyde which reacted with the sample at *p*H 4–5 for 30 min. at room temperature and for 3 hr. on a steam bath. We have found (unpublished work) that the catechol fragment does not react under these conditions, and thus the number of vacant reactive positions in the *A* ring can be determined. If substitution occurred in the *A* ring, its ability to react with formaldehyde would be reduced.

To avoid changes in the leuco-anthocyanins during purification crude samples of tannins were examined. They were commercial extracts of wattle bark (*Acacia mollissima*), 'Myrtan' (from wood and bark of *Eucalyptus wandoo*), mangrove cutch (from barks of *Rhizophora mucronata*, *Rhizophora apiculata* and *Bruguiera gymnorrhiza*). Kino collected from *Eucalyptus calophylla* was also examined. The tannin contents given in Table 1 have been determined by reaction with formaldehyde under acid conditions[8] and the formaldehyde uptake has been expressed on the basis of these figures.

Table 1. PROPERTIES OF CATECHINS AND TANNINS

Sample	Tannin (per cent)	Formaldehyde uptake		Anthocyanidin produced*	
		30 min. at 20° C. gm./gm. tannin	3 hr. at 100° C. gm./gm. tannin	Per cent	Calculated† as:
(+)-Catechin	116	0·146	0·082	—	—
(+)-Catechin polymer‡	103	0·062	0·048	—	—
Kino	99·6	0·041	0·059	12·1	cyanidin and pelargonidin (1 : 1)
'Myrtan'	67·7	0·011	0·043	10·5	cyanidin and pelargonidin (1 : 1)
Cutch	77·7	0·027	0·040	9·9	cyanidin and delphinidin (1 : 1)
Wattle	94·9	0·016	0·065	7·1	cyanidin

* Produced by heating with butanol and hydrochloric acid (ref. 10).
† Using values of Schou (ref. 11).
‡ Prepared at *p*H 8 phosphate buffer (ref. 9).

From the results in Table 1 it may be calculated that 1·62 moles of formaldehyde reacted with each mole of (+)-catechin, whereas 0·61 moles reacted with each basic unit of a (+)-catechin polymer[9]. This loss of one available position on polymerization supports the view that it is of the head-to-tail type.

When chromatograms of the tannins were sprayed with vanillin-hydrochloric acid, it was found that kino contained an appreciable portion of mobile flavans, whereas 'Myrtan' contained very little and none could be detected in the cutch. This spray reagent does not permit a reliable comparison of wattle extract with these tannins. Wattle produced the lowest amount of anthocyanidin from the leuco-anthocyanins on heating with butanol–hydrochloric acid[10] (Table 1). One of the factors possibly responsible for this low yield is that different types of linkages may exist in the wattle tannin.

The greater reaction of formaldehyde (formaldehyde uptake) with kino than with the other tannins at room temperatures may be due to the higher amount of monomeric flavans. However, this formaldehyde uptake is still lower than that of catechin or catechin polymer, showing that in these conditions there are fewer reactive positions in the *A* rings. The commercial tannin extracts showed different amounts of blockage to formaldehyde in the *A* ring.

Table 1 shows that, whereas the formaldehyde uptake of catechin polymer and catechin decreased on heating, it increased in the case of tannin extracts, the increase being lowest for kino and highest for wattle. The above decrease was found to be due to expulsion of formaldehyde during polymerization (unpublished work). While this reaction may occur in the tannins, the overall effect is an increase in formaldehyde uptake on heating. Some of this behaviour could be due to a difference in reactivity under different conditions. On the other hand, the results are consistent with the view that a labile grouping is split off from the *A* ring under the conditions of the test. It is known that polymeric flavandiols break down readily when heated with alcoholic hydrochloric acid. Thus, it is possible that they are also broken down under the conditions of the formaldehyde reaction, liberating further positions for attack by formaldehyde. If polymeric flavandiols are linked differently in the various tannins so that some are broken down to the monomers more readily than others, then different formaldehyde uptakes could be obtained on heating (Table 1).

In addition to the different amounts of reaction with formaldehyde, catechin polymer did not react with vanillin/hydrochloric acid, whereas the tannins examined did so. Consequently, the grouping that is linked to the *A* ring must be of such a nature that it does not de-activate this ring[10] for the vanillin/hydrochloric acid reagent.

Further distinction between catechin polymer and the tannins was shown by spectral data. At *p*H 8 catechin polymer showed a maximum at 410 mμ (see also ref. 9). This maximum was not observed in freshly prepared solutions of the tannins at *p*H 8, but on standing, cutch only showed maxima at 410 and 500 mμ. Thus, cutch contains a structure capable of change to one showing a spectrum similar to that of *Acacia catechu* and *Uncaria gambir* tannins[7].

These results will be discussed fully elsewhere.

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Characterization of Ficin

THE general attributes of ficin and its enzymic action have not been thoroughly described in the literature. The work of Winnick *et al.*[1] showed conclusively that ficin was a sulphydryl enzyme. More recently the kinetics of ficin on arginine derivatives have been studied[2]. In the present communication its electrophoretic and ultracentrifugal behaviour are described. The optimal conditions for activity and stability were also established. In further characterization of its properties, the effect of acetylation of its free amino-groups on the activity and stability was studied.

To prepare a sample suitable for electrophoretic and ultracentrifugal studies a procedure was adopted to permit proper equilibration of the crystalline suspension of enzyme with the buffers desired and to ensure a depressed oxygen level. 25 mgm. of ficin was dissolved in 3 ml. of buffer and inserted into a 'Cellophane' bag which was slipped over a test tube to form a thin layer of solution around the tube. The sample was then immersed in 400 ml. of buffer kept cold in an ice-bath, through which nitrogen had been passed for 15 min. Rapid dialysis was carried out by shaking the entire apparatus for 2 hr. while the gas was continuously bubbled through the buffer.

The electrophoretic and ultracentrifugal patterns indicated the relative homogeneity of the protein. The sedimentation constant was calculated to be 2·66 S. and was found not to vary with the *p*H. The isoelectric point is at *p*H 9·0.

The *p*H optimum for proteolytic activity of ficin, employing the method of Kunitz but with 0·01 *M* cysteine present, was determined. A broad optimum from *p*H 6·5 to 9·5 was observed.

Acetylation of the free amino-groups of ficin was carried out in a solution half saturated with sodium acetate and 0·15 *M* potassium cyanide. 100 mgm. of ficin dissolved in 5 ml. of this medium, cooled in an ice-bath, was acetylated with 0·6 ml. of acetic anhydride by adding aliquots of 0·1 ml. over a 1 hr. period. The *p*H was maintained above 4·0 throughout the reaction. 40 per cent of the amino-groups were acetylated as determined by ninhydrin colorimetric analysis. Neither the activity nor *p*H optimum was altered by this modification. From the fact that acetylation with acetic anhydride, which is specific for amino-groups[3], did not impair enzymic activity it may be concluded that most of the amino-groups are not essential.

The effect of varied concentrations of three reducing agents, cysteine, potassium cyanide and dimercaptopropanol, on the activity of ficin was also investigated. The results are summarized in Fig. 1. Activation by cysteine was constant between 5×10^{-3} and 5×10^{-2} *M* concentrations, likewise the activation by dimercaptopropanol remained constant but at a lower level. In contrast, the activity of the enzyme increases with rising concentrations of potassium cyanide to a maximum at 0·075 *M*.

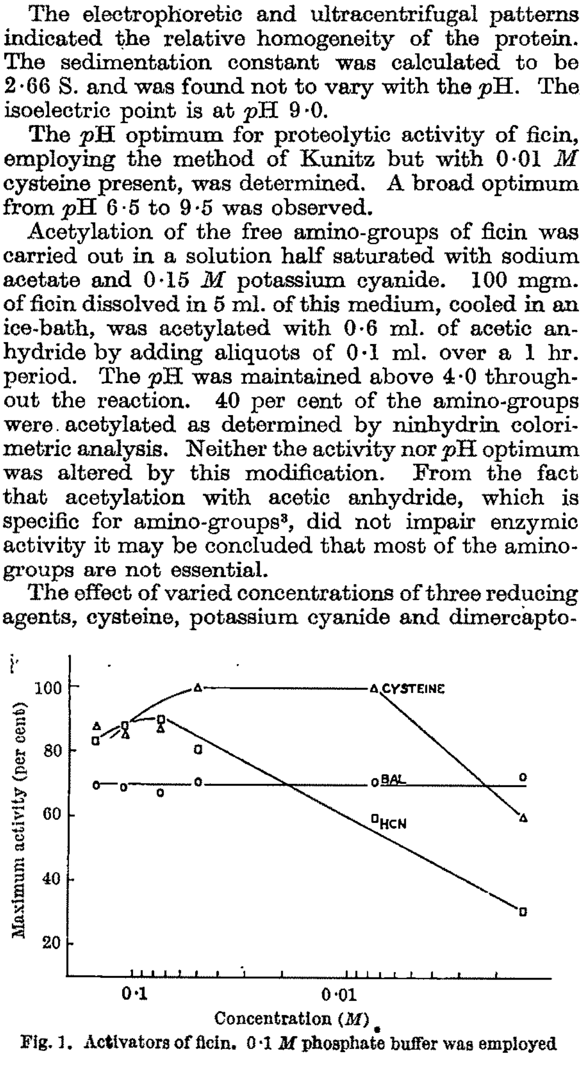

Fig. 1. Activators of ficin. 0·1 *M* phosphate buffer was employed

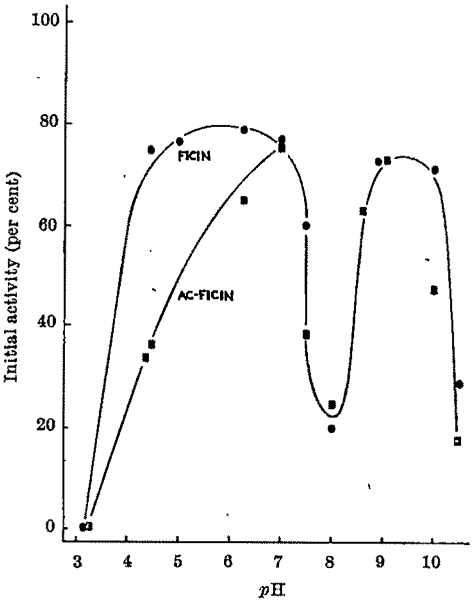

Fig. 2. *p*H stability of ficin and acetylated ficin. The enzymes were incubated for 2 hr. at 50° C. The 0·05 *M* buffers employed are as follows: glycine, *p*H 2·5–3·5; sodium acetate, *p*H 4·0–6·0; sodium phosphate, *p*H 6·0–8·0; sodium borate, *p*H 8·0–9·5; glycine, *p*H 9·5–10·5. 0·01 *M* cysteine was included in each buffer

The stability of ficin was investigated in 0·05 *M* buffers containing 0·01 *M* cysteine at a concentration of 0·33 mgm. per ml. An incubation period of 2 hr. at 50° C. was employed in these studies. The enzyme is stable between *p*H 4·5 and 9·5 except for a narrow zone around *p*H 8·0. These results are recorded in Fig. 2. The acetylated enzyme, which is also depicted in the same figure, presents similar stability properties in neutral or alkaline media, but in acid media it is considerably less stable than the native enzyme. The minimum exhibited by ficin is dependent, most probably, on the rate of auto-oxidation of cysteine rather than a property of the enzyme itself. This zone of instability near *p*H 8·0 can be effectively altered by increasing the concentration of cysteine. It was found that 0·025 *M* cysteine was optimal for stabilizing the enzyme at *p*H 8·0.

Employing 0·025 *M* cysteine, the *p*H stability was redetermined. The enzyme exhibited a more normal optimal stability near *p*H 7·5. Thus the true stability of the enzyme is that which is observed under these conditions of higher cysteine concentration.

The loss of stability in the acid-range upon acetylation of enzymes was previously noted with other enzymes[4-6]. It has been suggested that the groups governing the stability of the native enzyme do not necessarily influence the stability of the acetylated form. The principle that a few key groups are responsible for preservation of the characteristic native secondary structure of proteins can be maintained, provided it is extended to include the possibility that by redistributing overall charges through acetylation other groups may assume this function.

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Separation of Chalcones, Flavanones and Flavonols by Chromatography with Polyamide

POLYAMIDE had been used as an adsorbent in chromatography by Carelli, Liquori and Mele[1], as well as by Grassmann, Hoermann and Hartl[2], for the separation of phenols. Recently, Hoerhammer, Wagner and Leeb[3] used it for the separation of flavones and their glycosides, and for the quantitative removal of tanning substances from plant extracts containing flavones.

The complete conversion of chalcones into flavanones is very unusual, and separation by recrystallization is often difficult. It is possible, however, to fractionate chalcones and flavones on a column with powdered polyamide; the chalcone is retained in the upper part of the column, whereas the flavanone is readily eluted with water, aqueous alcohol or aqueous acetone respectively. By this means the simple chalcones can be separated from the corresponding isomeric flavanones; for example, 2-hydroxy-, 4′-hydroxy-, 4′-methoxy-, 3′-methoxy-4′-hydroxy-flavanones. The chalcone that remains in the upper part of the column can be eluted with absolute methanol. If plant extracts are used that contain both chalcones and flavanones, for example butin and butein, the best separation is obtained by aqueous alcohol mixtures. The plant extracts are either dried on, or triturated with, polyamide and the combination placed on a polyamide column. The flavanone is first eluted with mixtures of water and alcohols or ketones, and then the chalcone with the pure solvent. The concentration of the solvent mixtures used for the separation depends on the substance, and is found by the usual alteration of the elution medium in sorption chromatography.

It is often not easy to isolate pure flavanoids, as distinct from the fraction containing these substances, and the process often involves considerable losses of substance[4]. Chromatographic procedures are especially important in this connexion but all the usual substances known as adsorbents cannot be used for the separation of flavonols, especially those that adsorb these compounds irreversibly. Polyamide is an adsorbent that has not hitherto been examined in detail in this respect.

In further work on the hydroxy phenyl-benzo-γ-pyrones it was found that separation of flavonol and flavanonol was possible on a column of polyamide. For these investigations a crude sample of dihydroquercetin that contained a small amount of quercetin was used. The extract obtained from the crude flavanonol by means of diethyl ether was dried on powdered polyamide, and then put on a column containing the same adsorbent made up in water. By elution with aqueous ethanol (20–30 per cent of ethanol) the dihydroquercetin was first obtained and then, by elution with pure ethanol, the quercetin. Both of them were paper-chromatographically pure.

I wish to thank Dr. D. W. Glennie, of the Oregon Forest Research Center, Cornwallis, for the dihydroquercetin.

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Reactivity of Sulphonyloxyl Groups with Halides in the Carbohydrate Series

IT has recently been shown[1] that refluxing 6-O-mesyl-1 : 2-3 : 4-di-O-*iso*propylidene-D-galactopyranose[2] (i) and 3 : 5-O-benzylidene-6-O-mesyl-1 : 2-O-*iso*propylidene-D-glucofuranose[3] (ii) with potassium fluoride in ethanediol, yields the 6-deoxy-6-fluoro-D-galactopyranose and D-glucofuranose derivatives, respectively. A notable difference in the reactivity of the two sugars towards potassium fluoride was found (Table 1).

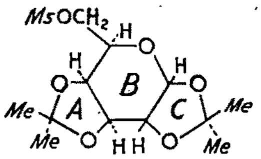
Table 1

Compound	Temperature (°C.)	Time (min.)	Per cent yield of fluorosugar
6-O-Mesyl*-D-galactose derivative (i)	200	75	60
6-O-Mesyl-D-glucose derivative (ii)	200	2·5	75

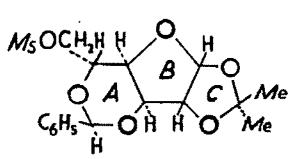
* Mesyl = $-SO_2CH_3$.

A similar qualitative difference in the reactivity of terminal sulphonyloxyl groups of the above D-galactose and D-glucose derivatives has also been observed in the case of iodine exchange reactions, using sodium iodide in acetone (review by Tipson[4]). It is to be expected that the difference in size (and electronic properties) between the iodide and fluoride ions will be one of the many factors which will influence the reactivity of the sulphonyloxyl groups. These results with fluorine and iodine exchange reactions, however, suggest the importance of the actual stereochemistry of the sugar molecule in exchange reactions of this type.

Structures (I) and (II), representing the D-galactopyranes (i) and D-glucofuranose (ii) derivatives, respectively, in their most stable *cis*-anti-*cis* (rings *ABC*) steric arrangement, are written in accordance with the convention suggested by Mills[5a]. It is significant that if ring *B* in (I) and ring *A* in (II) retain their most stable *C*1 chair conformation[6], then the residue $—CH_2O\mathit{Ms}$ is equatorially disposed in (I) and axial in (II).



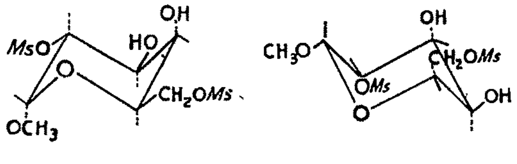
(I)



(II)

It has already been pointed out by Mills[5b] that in iodine exchange reactions, terminal axially disposed sulphonyloxyl groups in *cis* bicyclic diacetals are more readily replaced than equatorial. The fluorine and iodine exchange reactions on (I) and (II) support this view.

It is interesting to note that when (I) is converted to methyl 2 : 6-di-O-mesyl-D-galactopyranoside (III) iodine exchange at C_6 under identical conditions now proceeds much more readily[7]. This may be due to the fact that the removal of the *iso*propylidene groups from (I) now permits the —CH_2OMs residue of (III, *C*1) to take up an axial disposition (III, 1*C*).



*C*1 1*C*

(III)

Further experiments with carbohydrates of known and fixed conformation are in progress designed (*a*) to establish by kinetic studies the influence of steric factors and size of attacking anion on the reactivity of sulphonyloxyl groups, and (*b*) to provide a means of distinguishing between axial and equatorial substituents in carbohydrates where conformation is uncertain.

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Itaconicoxidase: an Enzyme from an Ultra-Violet-induced Mutant of *Aspergillus terreus*

During an investigation of the metabolic patterns of ultra-violet-induced mutants in *Aspergillus terreus* Thom[1,2], a soluble, cell-free enzymatic extract, that can oxidize itaconic acid to itatartaric acid, was prepared from the mycelium of a morphologically altered variant.

Cell-free extracts are obtained from surface cultures of the organisms, grown at 28° C., on 100 ml. portions of the medium described in a previous publication[2]. The mycelial pad covers the surface 4–6 days after inoculation. The original culture medium is replaced by 100 ml. distilled water, and the mycelium is allowed to stand in this water for 1 hr. at room temperature. All subsequent operations are carried out in the cold-room. The mycelium is washed with several portions of ice-cold water and is then ground in a mortar with 3 ml. of 0·3 *M* citrate buffer, *p*H 4·16, in the presence of about 1·5 gm. of glass beads. The paste is diluted with 7 ml. of citrate buffer and centrifuged at 1,500*g* for 20 min. at 0° C. The supernatant is passed through a filter paper, yielding an opalescent solution with a slight orange–tan colour. Such solutions have *p*H values between 4·1 and 4·2, and contain some itaconic acid, or itatartaric acid released from the cells during the grinding process.

The enzymatic oxidation reaction of itaconic acid was followed manometrically by standard Warburg techniques in air at 37° C. The total volume was 3·2 ml., containing 1·5 ml. of 0·25 per cent itaconic acid substrate in citrate buffer; 1·5 ml. cell-free enzyme in citrate buffer, *p*H 4·16; and 0·2 ml. of 2 *N* potassium hydroxide were in the centre well.

The other details of the manometric methods and culture conditions, as well as chemical analytical methods used for sugars and acids, the irradiation techniques for the production of the mutations, and the selective work are described in preliminary studies[3].

Typical results of manometric studies of the oxidation of itaconic acid by enzymes prepared from the mycelium of the parent strain (*A*) and of the mutant (*B*), as well as oxygen uptake by enzyme controls in the absence of substrate (endogenous respiration, *E*) are shown in Fig. 1. The enzymatic oxidation of itaconic acid expressed as percentage of the original quantity is shown in Fig. 2. The enzyme obtained from the mutant, which is most active over the *p*H range 4·0–4·2, readily oxidizes itaconic acid forming approximately stoichiometric amounts of itatartaric acid. On the other hand, the cell-free extracts prepared from the unirradiated parent strain did not oxidize itaconate.

The dependence of oxygen consumption on age, concentration, *p*H, inhibitors and oxygen pressure

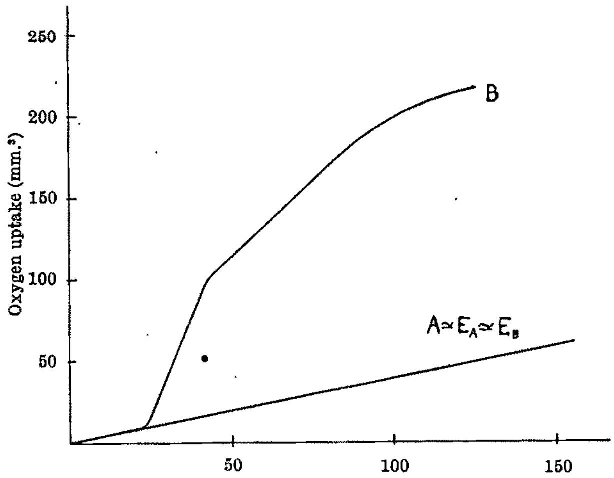

Fig. 1. For key see text

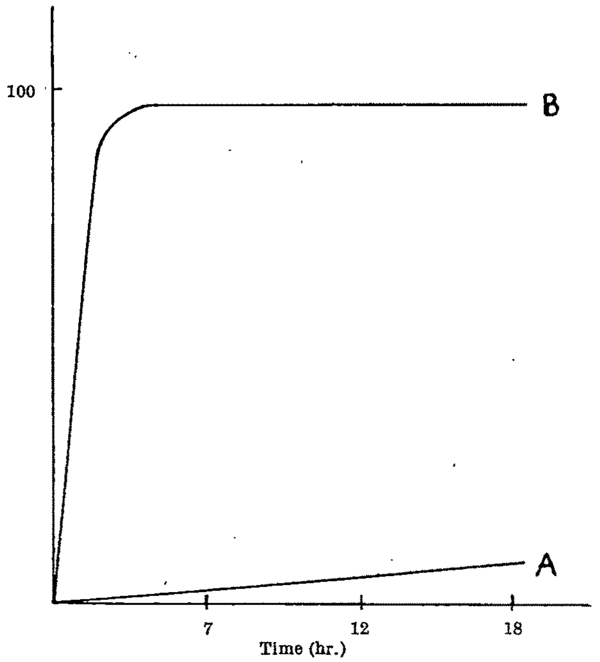

Fig. 2. For key see text

was tested. The oxygen consumption was found to be largely independent of the itaconic acid concentration, and the rate of oxygen uptake decreased with time. The course of oxygen uptake can be divided into two parts, an initial rapid phase, and a second, very slow phase. As the pH is decreased, the rate of itaconic oxidation increases, the oxygen consumption at pH 4·2 being about twice that at pH 7. Cyanide, hydroxylamine and iodoacetic acid, even at concentrations of 0·01 M, have no effect on the oxidation of itaconic acid. Dialysis does not decrease the activity.

The rate of oxidation is proportional to the oxygen pressure, the increase on changing from air to oxygen being generally 100–200 per cent.

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Uptake and Utilization of DL-[2-^{14}C] Mevalonic Acid by *Hevea brasiliensis*

THE high efficiency of incorporation of DL-3-hydroxy-3-methyl-[2-^{14}C] pentano-5-lactone (DL-[2-^{14}C] mevalonic acid) into cholesterol in rat-liver homogenates was first shown by Tavormina, Gibbs and Huff[1], who concluded that the lactone could provide an active 5-carbon isoprenoid unit which was used in direct biosynthesis. It was further found that this unit was derived from the lactone by elimination of C_1 as carbon dioxide[2]. These results have been confirmed and extended to squalene biosynthesis[3-5], the pattern of isotopic labelling determined by degradation agreeing with that required for the synthesis of squalene from intact 5-carbon units[3]. Further proof of a general utility of the lactone in isoprenoid biosynthesis is shown by its incorporation into β-carotene in *Phycomyces blakesleeanus* and carrot slices[6], and in *Mucor hiemalis*[7]. The present communication describes briefly the further extension of this field to the uptake and utilization of DL-[2-^{14}C] mevalonic acid by a rubber-producing plant, *Hevea brasiliensis*.

The plants used were 2-year old seedlings, grown in a greenhouse. They were in active growth, and carried large healthy leaves. The uptake of [2-^{14}C] mevalonic acid was best carried out by applying a solution in neutral phosphate buffer to the upper surfaces of leaves, or to lightly scraped areas of the main-stem. To aid uniform leaf application, a trace of wetting-agent ('Tween') was added to the solution. Hypodermic injection was unsuccessful, even when applied to the soft upper stem tissues.

Absorption of the lactone by the leaves was rapid, the count-rates of the upper and lower surfaces being about equal after 5 hr., thereafter remaining almost unchanged. Translocation of activity through the plant did not occur, even to neighbouring untreated leaves, and none could be induced by tapping the plant at several points along the stem. After two days the active leaves were harvested, washed thoroughly with water, ground with sand, and extracted with warm water. All the activity was water-soluble (total count-rate 12,750 c.p.m.), and re-extraction of the aqueous solution with petroleum-ether resulted in the transfer of 52 per cent of its activity. It was shown by paper chromatography that all the activity remaining in the aqueous solution was due to unchanged mevalonic acid. The petroleum-ether extract was chromatographed on a column of 'Celite', and eluted with the same solvent. At least four coloured components were resolved, of which a yellow pigment, which ran with the solvent front as a diffuse band, was completely separated from the remaining bands. This first fraction contained 96 per cent of the activity applied to the column. The residual activity on the column was eluted in the same position as a control addition of [2-^{14}C] mevalonic acid.

The absorption spectra of the active pigment in several solvents agreed closely with those known for α-carotene, and this identity was confirmed by the dextro-rotation shown by the pigment solutions. If it is assumed that only one of the enantiomorphs is physiologically active, the above results show that virtually all the available mevalonic acid absorbed by the leaves was converted to α-carotene.

Application of mevalonic acid to the stem was designed to show whether its efficient use for carotene synthesis in leaves was masking a possible alternative use for rubber synthesis. Again, absorption was rapid, activity moving down the stem from the point of application to appear in the lower newly formed side-shoots and leaves after ½ hr. No activity could be detected moving up the stem.

After three days, leaf activity accounted for about 50 per cent of the total (5 × 10^5 c.p.m.) applied to the stem, and was completely soluble in water. In this case, however, no activity had been incorporated into the carotene fraction, and only a small amount was due to unchanged mevalonic acid. Paper chromatography with a solvent system of n-butanol/water/90 per cent formic acid (10 : 10 : 3 by volume) showed most of the leaf activity to be associated with a single component (R_F 0·12), which probably possessed more polar groups than mevalonic acid (R_F 0·72).

The remainder of the plant, namely, the main stem and side-shoots, was reduced to a fine pulp, and extracted successively with water, ethanol, acetone, ether, and benzene. About 30 per cent of the applied activity was recovered in the aqueous extract, and 20 per cent in the ethanol extract. All other extracts and residues were inactive.

The component with R_F value 0·12 appeared in both aqueous and ethanolic solutions, the latter also containing an active substance (R_F 0·93) which was probably a carboxylic acid.

It may be concluded that, under the conditions of these experiments, mevalonic acid was not incorporated into rubber in *Hevea*, and that it was converted in the stem to products unable to enter the pathway of carotene synthesis which can operate with high efficiency in the leaves.

Fuller details of this work will be published elsewhere at a later date.

We wish to express our thanks to the Dunlop Rubber Co., Ltd., for permission to publish this communication.

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Action of Testosterone Propionate and 4-Chlorotestosterone Acetate on Protein Synthesis *in vitro*

The protein anabolic activity of testosterone propionate is well established[1]. It has been shown that an increase in the rate of uptake of labelled glycine occurs in slices of kidney from mice treated with this substance[2]. Incorporation of labelled glycine into liver proteins does not seem to be affected.

As the action of testosterone propionate on protein synthesis might depend on the condition of the tissue, we have studied the incorporation of glycine-1-^{14}C into slices of resting and regenerating livers from animals treated with testosterone propionate.

The effects of a new compound, 4-chlorotestosterone acetate, recently synthesized by Camerino, Patelli and Vercellone[3], have also been studied. This substance possesses powerful myotrophic and weak androgenic activity, as measured by increase in weight of levator ani muscle and ventral prostate gland, respectively[4]. Having greater anabolic and lesser androgenic effects than testosterone propionate similarly administered, it may have considerable therapeutic value as an anabolic agent.

Castrated male rats, weighing 200–250 gm., were used throughout our experiments. They were treated subcutaneously with 2 mgm. of testosterone propionate or 4-chlorotestosterone acetate once a day for three days. The first injection was done 2 hr. after partial hepatectomy in the case of the animals with regenerating liver. At the end of the treatment (72 hr. from the start, 74 hr. from hepatectomy) the rats were killed by decapitation, the livers quickly removed and sliced by hand with a razor. The slices were then placed into the main chamber of a Warburg flask containing 3·0 ml. of phosphate-saline[5]. After 10 min. equilibration, the labelling reaction was started by transferring 2 μc. (3·4 μmoles) of glycine-1-^{14}C in a volume of 0·4 ml. from the side-arm into the main chamber of the flask: this was within 30 min. of the death of the animal. The labelling reaction lasted 1 hr.; the experimental conditions and counting techniques were the same as described by Bernelli-Zazzera and Guidotti[5].

The results are shown in Table 1.

Table 1. INCORPORATION OF GLYCINE-1-^{14}C INTO THE PROTEINS OF SLICES OF RESTING OR REGENERATING LIVERS FROM ANIMALS TREATED WITH TESTOSTERONE PROPIONATE OR 4-CHLOROTESTOSTERONE ACETATE

Counts/min./mgm. of protein. Means of five experiments ± S.E.

	Resting	Regenerating
Controls	165·3 ± 14·0	257·8 ± 40·2
Testosterone propionate treated	152·9 ± 10·8	326·0 ± 36·1
4-Chlorotestosterone acetate treated	165·1 ± 21·6	409·6 ± 47·9

Sum of squares between experiments, within conditions = 73,274·75 (8 d.f.).

The Bartlett test is not significant. Therefore we made an analysis of variance, considering that three rats (control and one treated with each drug) were used throughout one experiment. It was possible to conclude that: (1) slices of regenerating livers incorporate glycine at a rate significantly higher than that of resting livers ($P < 0{\cdot}01$). (2) Slices from rats treated with testosterone propionate or 4-chlorotestosterone acetate incorporate glycine at a rate significantly higher than untreated controls ($P < 0{\cdot}05$). (3) There is no difference between the effects of the two treatments ($P > 0{\cdot}05$). (4) The effects of the treatments largely depend on the state of the tissue ($P < 0{\cdot}05$); this can be seen from Table 1, where the treatments are effective in enhancing glycine incorporation into liver proteins only in the case of regenerating livers, when the restoration of cell structures takes place and the rate of protein synthesis reaches its maximum. Therefore, the hypothesis that testosterone propionate and 4-chlorotestosterone acetate are mainly active on the synthesis of cell proteins is not inconsistent with our results.

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Effect of Atmospheric Contaminants on Paper Chromatography of Urinary Indole and Phenol Acids

Samples of human urine have been examined for indole and phenol acids as a matter of routine in this laboratory for several months; the methods used for extraction and two-dimensional paper chromatography were described earlier[1,2]. The chromatograms were satisfactory until certain days in April, when the normally pink and purple spots given by indoles with *p*-dimethylaminobenzaldehyde showed a diminished colour intensity and brown discoloration. The colours became so weak in May that indole spots could not be seen with certainty. Unlike the indoles, the phenolic acids gave colours which were normal immediately after spraying with diazotized sulphanilic acid, but which faded and were discoloured afterwards to an increasing extent. No improvement was obtained when the components of the chromatographic solvents were purified extensively.

The occurrence of chromatographic difficulties appeared to coincide with an increased level of atmospheric contaminants. The eye-irritating haze known as 'smog', develops frequently in the Los Angeles area where topography and meteorological conditions favour the formation of a large stagnant air mass and the accumulation of fumes from numerous industries and other sources. 'Smog' contains ozone, organic peroxides, nitrogen oxides and other components[3]. The 'smog' level was low early in 1958 because of unusually heavy rains, but became noticeable in April and marked in May; an atmospheric ozone content of 0·35 parts per million was reported in Pasadena on May 15.

Several other features suggested that oxidative atmospheric contaminants were responsible for the destruction of indole spots on chromatograms. Ozone has been used preparatively to rupture the pyrrole ring of indole compounds[4]. The instability of ozone and organic peroxides in alkaline media is well known; on the other hand, ozonization is frequently carried out in acetic acid. These properties may explain why one-dimensional chromatograms developed in *iso*propyl alcohol/ammonia/water (8 : 1 : 1) furnished indole spots with almost normal colours with *p*-dimethylaminobenzaldehyde at a time when those run in benzene/propionic acid/water (100 : 70 : 5) did not.

A pertinent counterpart to these observations was provided by a report concerning the adverse effects of 'smog' on the response of plants to indoleacetic acid[5]; the 'smog' was eliminated by filtering the air through charcoal[6]. This approach also afforded a solution to the present problem. Two sets of two-dimensional chromatograms were prepared from four different urine extracts. One set was dried in the hood as usual; *p*-dimethylaminobenzaldehyde revealed faint brown (instead of blue) spots of only 5-hydroxyindoleacetic acid. The second set was dried in empty chromatography jars, after each solvent and after spraying, by a current of air which had passed through a 2-l. aspirator bottle filled with 8–12 mesh activated charcoal; 14 indole spots with normal colours were observed on this set of chromatograms. A charcoal unit large enough to ensure a 'smog'-free room is being designed.

The formation of 'smog' is a problem of increasing importance in densely populated and heavily industrialized cities. These findings, therefore, may be of interest to investigators working in such areas with small amounts of compounds or biological systems which are sensitive to the action of atmospheric contaminants.

We wish to thank Dr. A. J. Haagen-Smit and Dr. F. W. Went for helpful suggestions. This study was supported by a grant from the Ford Foundation.

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Inhibitory Action of Ethyl Mercaptan on Intracellular Tubercle Bacilli

We have previously described the anti-tuberculous activity in mice of ethyl mercaptan and its derivatives[1,2]. The marked activity which was observed did not seem to correspond with the slight bacteriostatic action of ethyl mercaptan against *Mycobacterium tuberculosis in vitro*. Since the bacilli in tuberculosis are intracellular, we decided to test the effect of ethyl mercaptan against bacilli so located. For this purpose we used the method described by Suter[3] in which tubercle bacilli are grown *in vitro* within monocytes derived from peritoneal exudates of normal guinea pigs. Because of the high volatility of ethyl mercaptan it was necessary to modify Suter's method of incubating the cover-slips on which the monocytes and bacteria were attached. The tubes containing the cover-slips were sealed by heat before they were incubated, at an angle of 30° from the vertical, without rotation. This modification still allowed good growth of the bacteria and isoniazid was highly effective (Table 1).

Four cover-slip preparations from each treatment were stained at intervals of 1, 3, 5 and 7 days and 200 monocytes were examined on each slide and classified as containing 0, 1–10, 11–20, and more than 20 bacteria respectively. The activity of an inhibitory compound can be seen most conveniently from the percentage of cells containing more than 20 bacteria in the 7-day cultures.

Ethyl mercaptan was inhibitory at concentrations of the order of 10 μgm./ml., methyl mercaptan was ineffective; indeed it partially antagonized the effect of ethyl mercaptan. This is in accordance with our observations in mice[2]. The specificity of this effect was demonstrated by the failure of ethyl mercaptan to inhibit the intracellular growth of a strain of bacilli which had been made resistant to treatment with thiol esters in mice[2] (Table 1). Several potential metabolites of ethyl mercaptan, including methyl ethyl sulphide, methyl ethyl sulphone, β-hydroxyethyl methyl sulphide and β-hydroxyethyl methylsulphone were inactive, whereas the diethyl disulphide was active.

Table 1

Treatment or conditions of growth	Percentage of monocytes containing more than 20 bacteria at 7 days
Open tubes	86
Sealed tubes	97
Sealed tubes with isoniazid 0·1 μgm./ml.	25
Ethyl mercaptan 100 μgm./ml.	9
Ethyl mercaptan 10 μgm./ml.	18
Ethyl mercaptan 1 μgm./ml.	35
Untreated controls	35
Antagonism	
Ethyl mercaptan 100 μgm./ml.	12
Methyl mercaptan 100 μgm./ml.	40
Ethyl mercaptan 100 μgm./ml. + methyl mercaptan 100 μgm./ml.	19
Untreated controls	34
Strain resistant to ethyl thiol esters (ref. 2)	
Ethyl mercaptan 100 μgm./ml.	83
Isoniazid 1 μgm./ml.	5
Untreated controls	80
Normal sensitive strains	
Ethyl mercaptan 100 μgm./ml.	25
Untreated controls	68
Human monocytes	
Ethyl mercaptan 100 μgm./ml.	10
Untreated controls	63

The inhibitory action of ethyl mercaptan was also demonstrated using human monocytes obtained from a patient suffering from monocytic leukæmia (Table 1).

We thank Mr. F. D. Vernon for his skilled technical assistance in this work.

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A Simple Method for making Starch-gel Electrophoretic Strips Transparent

Starch-gel electrophoresis, as introduced by Smithies[1], has proved superior to both free and filter-paper electrophoresis for separating protein mixtures[2–6]. However, the opacity of the strips excludes the possibility of direct quantitative evaluation of separated proteins, though this is possible with the other two electrophoretic methods. This problem was successfully solved recently by Fine and Waszczenko[7], who prepared starch-gel suitable for direct quantitative evaluation by transmission photometry. A simpler and quicker method for obtaining transparency of the strips is presented here.

At the end of the run, the standard $\frac{1}{4}$-in. thick starch-gel strip is transferred into a $\frac{3}{16}$-in. deep slicer of the type described by Smithies[1]. This is then covered with a $\frac{1}{16}$-in. deep slicer, and the cutting is performed lengthwise between these two. In this way the upper portion of the strip is removed and then discarded. The rest of the strip is transferred into a $\frac{1}{8}$-in. deep slicer, then covered and sliced as above except that this slice is transferred to the staining dish. Similarly, another slice is cut in a $\frac{1}{16}$-in. deep slicer and is also transferred to the staining dish. In this way two $\frac{1}{16}$-in. strips of the central portion of the original strip are obtained.

Staining the strips is carried out in a saturated solution of buffalo black in a methyl alcohol/water/acetic acid (50 : 50 : 1) solution for a period of 2 min. The same solution, but without the dye, is used for removal of the background stain, which occurs after the strips have been left in the washing solution for 12–16 hr. Strips are then transferred to a tray containing a 10 per cent solution of acetic acid and boiled for 30 sec., after which the whole is cooled to room temperature. Such a procedure renders stained strips transparent. Strips should not be removed from the acetic acid solution before cooling since they are very fragile. Transparency of the strips treated thus is greater than that of freshly formed gels, while their consistency is of the same order.

It is worth mentioning that certain protein fractions which are present in minute amounts are more readily visible after the strips are made transparent.

In order to evaluate these strips photometrically, they are transferred into a $\frac{1}{16}$-in. deep slicer and covered by a 'Plexiglass' strip. Care should be taken not to trap any air bubbles below or above the strip. This can be achieved by carefully laying the strip on the slicer and delivering a sufficient amount of acetic acid solution around and on the top of the starch-gel strip prior to its covering.

If one wishes to preserve starch-gel strips for future reference, one should transfer them back to the methyl alcohol/water/acetic acid solution, in which they solidify after resuming their original opacity.

I wish to acknowledge the help and assistance of Dr. O. Smithies in introducing the starch-gel electrophoresis method in this laboratory.

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Thermal Decomposition of Antibiotics

Previous work on the thermal decomposition of the tetracycline series of antibiotics in which aureomycin, terramycin and tetracycline were studied[1] has been extended to include erythromycin, leucomycin base, oleandomycin phosphate and carbomycin.

The thermograms were obtained by use of an automatic recording thermobalance[2], using the same procedure as before[1]. The antibiotics were obtained as commercial samples and were not further purified before pyrolysis.

The thermograms of the four antibiotics are given in Fig. 1. Although a detailed analysis of the decomposition mechanism is difficult to make, the loss of bound water is readily detected. Any further interpretation of the decomposition process is difficult to do because of the complex structure of the antibiotics and also because the pyrolysis was carried out in air.

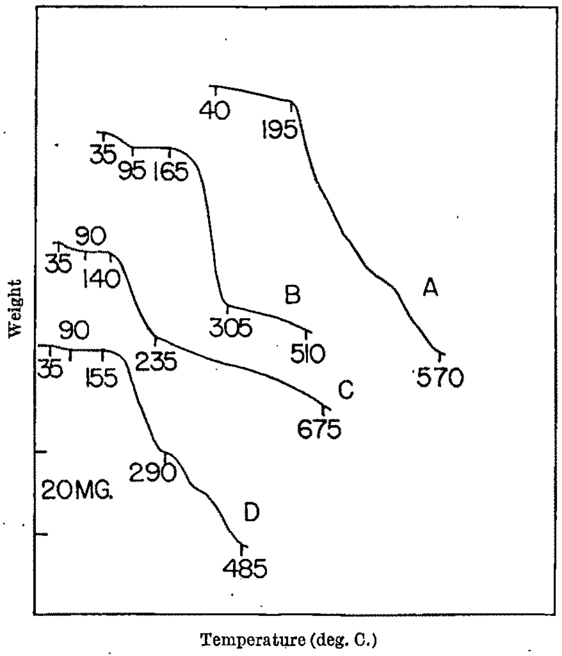

Fig. 1. Thermal decomposition of antibiotics: *A*, carbomycin; *B*, erythromycin; *C*, oleandomycin phosphate; *D*, leucomycin base

Erythromycin. The first loss in weight for this antibiotic was observed at about 35° C. After this initial loss in weight, a horizontal weight-level was found extending from 95° to 165° C. This first loss in weight is thought to be due to the evolution of loosely bound water. Previous studies have shown that this water is completely lost at 55° C. under reduced pressures[3]. Beyond 165° C. the antibiotic decomposed rapidly, leaving a small amount of carbonaceous matter (less than 10 per cent) in the thermobalance pan at 510° C.

Carbomycin. The antibiotic lost weight continuously from 40° to 570° C. Starting at 40° C., the loss in weight was quite slow until 195° C. was reached, when it began to decompose rapidly. As with erythromycin, some carbonaceous matter remained at 570° C.

Oleandomycin phosphate. The first loss in weight was observed at 35° C. After this initial loss, a nearly horizontal weight-level was observed from 90° to about 145° C. Beyond 145° C. the antibiotic decomposed rapidly, giving a break in the curve at 235° C., then further decomposition up to 675° C. Since this was a phosphate salt, the phosphate was left behind with the unoxidized carbonaceous matter.

Leucomycin base. After an initial loss in weight beginning at 35° C., a horizontal weight-level was observed from 90° to 155° C. Beyond 155° C., the antibiotic decomposed rapidly, giving a break in the curve at 290°. Further decomposition then occurred above 290° C. to give a small amount of carbonaceous matter at 485° C.

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Separation and Determination of the Dissociation Constants of Chelidonine and Protopine by Paper Chromatography

IN connexion with the chromatographic separation of alkaloids of *Chelidonium maius* L.[1], I found alkaloids giving rather big spots with a tendency to form tails. This is connected, among other things, with the dissociation constant (K_B), the value of which influences the course of the chromatographic process, organic electrolytes having different values of K_B in the water phase and the organic phase of dissociation.

By the use of buffer solutions and a proper choice of *p*H, the degree of dissociation can be regulated and thus the distribution ratio. This also affects the shape and the rate of migration of bands.

Attempts were made at separating chelidonine and protopine by means of buffered paper. The application of the methods of Waksmundzki *et al.*[3,4], who use a slightly moistened buffered paper, reduced the duration of the chromatographic process significantly. The dissociation constants of the alkaloids which were also calculated from formulæ[5] could also be determined. Moistened paper is slightly adsorptive, so continuous counter-current extraction takes place. Whatman No. 4 paper and the apparatus described by Waksmundzki and Soczewiński[4] were used. The mobile phase was chloroform, which is a good solvent for the two alkaloids. Its low viscosity considerably shortened the time of analysis. The chromatogram was developed over 15 cm.

The initial attempts, using moistened but unbuffered paper, gave negative results: the alkaloids migrated with the solvent front ($R_F = 1$).

In buffering the paper seven liquids in the *p*H range 1–6·45 were prepared. The values were checked with a *p*H-meter.

In order to determine the optimal value of the 'moistening index',

$$W = \left(\frac{\text{weight of moistened paper}}{\text{weight of dry paper}}\right)$$

the studies were carried out on paper buffered at *p*H 2. The effect of moistening the paper on the behaviour of the alkaloids and the duration of the chromatographic process were observed. The results are shown in Table 1.

It can be seen from Table 1 that 1·5 is the best value of W_z since the separation was obtained in a

Table 1. EFFECT OF MOISTENING THE PAPER ON THE R_F VALUE AND DURATION OF THE CHROMATOGRAPHIC PROCESS

Alkaloid	R_F with W_z = 1	1·5	1·75
Chelidonine	0	0·53	0·57
Protopine	0	0	0
Time (hr.)	1	1	4

comparatively short time. This value was used in further work.

Table 2 illustrates the dependence of R_F on the pH of the aqueous phase.

As appears from Table 2, acidification makes a good separation possible. The spots were distinct after development with Dragendorff's reagent, and did not form tails.

From Fig. 1 it can be seen that the two alkaloids have different dissociation constants. Assuming that the best separation is obtained when the arithmetical mean of the two values is ½, the optimal value for pH will be 2·9–3·5. In this range protopine has moved from the start line and chelidonine has not reached the front (the mean R_F value is about 0·45).

The points marked (+) were obtained experimentally, whereas those marked (O) were calculated using the equation deduced by A. Waksmundzki and E. Soczewiński[5]:

$$R_F = \frac{kr}{kr + 1 + \dfrac{K_B}{[\mathrm{OH}^-]}}$$

where $[\mathrm{OH}^-]$ is the concentration of hydroxyl ions in the aqueous phase; k is the partition coefficient of the substance under examination between the organic phase and the water phase; r is the ratio of the volume of the organic phase to that of water; and K_B is the dissociation constant of the base in question.

The experimental results served to determine the dissociation constant of the alkaloids under examination. From the difference in weight between a moistened strip and one that had been chromatographed with chloroform, the weight of chloroform in a known part of the strip was calculated. This weight was converted to a volume, and hence a value of 1·86 was obtained for r.

In order to determine k, weighed portions of the alkaloid were dissolved in chloroform and shaken with an equal volume of water. The aqueous phase was titrated with 0·05 N hydrochloric acid and the amount of alkaloid calculated. These results were checked by weighing the residue of alkaloid after the solvent had been evaporated from the chloroform phase. k was found to be 23·4 for chelidonine and 29·5 for protopine.

Substitution of these values of k and r in equation (1) gave $3{\cdot}8 \times 10^{-11}$ and $9{\cdot}73 \times 10^{-9}$ as the dissociation constants of chelidonine and protopine respectively.

Table 2. DEPENDENCE OF R_F ON THE pH OF THE BUFFER

pH	R_F of chelidonine	R_F of protopine
1·00	0·04	—
1·75	0·22	—
2·20	0·53	0·0
3·50	0·94	0·13
4·60	0·98	0·63
5·68	0·99	0·93
6·45	1·00	0·98

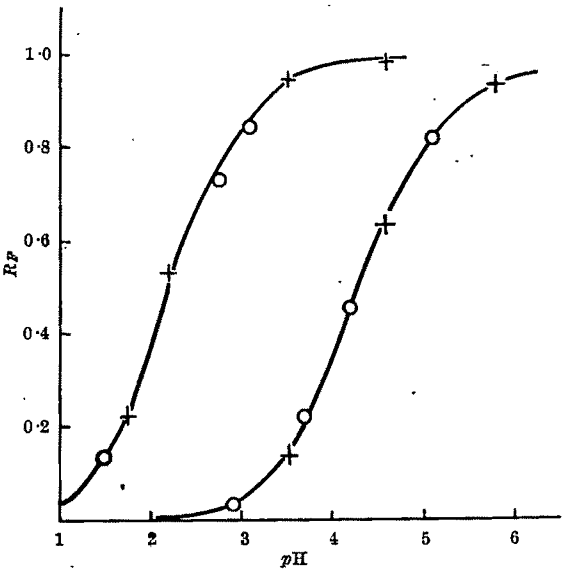

Fig. 1. Relation between R_F and pH for chelidonine and protopine. For key, see text

Thus the use of moistened, buffered paper permitted the separation of the substances under examination and the calculation of their dissociation constants. Because of the great differences in the partition coefficients of these alkaloids, a good separation is to be expected with Craig's countercurrent extraction method, using a buffer solution of pH 3·5 and chloroform.

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Riboflavin in Yellow Semen

MOST specimens of bull semen are almost white, but during the course of unrelated studies[1] on spermatozoa it was observed that the semen from one particular bull was quite yellow. The colour was confined to the plasma fraction and ultra-violet light produced a green fluorescence similar to that emitted by riboflavin. Other reports[2-4] have since been noted which suggest that the yellow pigmentation of bull semen may be attributed to riboflavin, and recently eight bulls producing yellow semen have been located, thus permitting a more critical and extensive investigation. The production of yellow semen was characteristic of these bulls, which were located in scattered parts of Australia and New Zealand. All bulls producing yellow semen were of the Friesian breed, and six were the first, second or third generation descendants of one sire. The pigmentation apparently does not affect the fertility of the semen since the bulls were in use at artificial insemination centres and the spermatozoal concentration and morphology were normal.

Qualitative tests showed that the yellow pigment had the properties of riboflavin and confirmation was obtained by chromatography of ethanol extracts of the semen using 5 per cent disodium hydrogen phosphate, *n*-butanol/acetic acid/water (4 : 1 : 5) and methanol as solvents. Light blue spots, one corresponding to lumichrome, were also present and an unknown violet spot which ran well ahead of riboflavin in *n*-butanol/acetic acid/water but remained at the origin in 5 per cent disodium hydrogen phosphate.

Quantitative aspects were studied by estimating the riboflavin content of sixteen yellow ejaculates and nine control white ejaculates. In the estimations of riboflavin[5] by conversion to lumiflavin, the preliminary chloroform extract of yellow semen was also found to give a fluorescence. This was measured quantitatively and expressed as the amount of riboflavin which on irradiation in alkaline solution gave an equivalent fluorescence. The riboflavin (mean 18·9 μgm./ml., population standard deviation 6·0) and flavin-soluble chloroform (mean 19·1 μgm./ml., standard deviation 6·3) content of the yellow samples were each about forty times that of the colourless samples and sufficient to account for the pigmentation. Both first and second yellow ejaculates obtained at any one time from individual bulls had a high flavin content which showed little variation although different samples were collected at intervals over a period of several months. It is particularly interesting that the ratio of riboflavin to flavin soluble in chloroform remained fairly constant at unity. Neither niacin[5] nor thiamin[5] values differed greatly between the groups, and the fructose levels for fourteen yellow ejaculates (mean 458 mgm. per cent, standard deviation 86) were normal.

On standing for several hours the yellow colour of the semen fades. Analysis demonstrated that this was due to the breakdown of riboflavin by sunlight rather than any metabolic activity of the spermatozoa. Chromatography showed that the lumichrome content increases at the expense of riboflavin. Ribitol, which might be expected to result from the photolysis of riboflavin, is not utilized by bull spermatozoa since the addition of 1 mgm. to 1 ml. of washed cells failed to increase the uptake of oxygen.

The results clearly establish that the yellow coloration of bull ejaculates is due to riboflavin. Yet other flavins, particularly one soluble in chloroform, are present in high concentrations even when the most rigorous precautions are taken to exclude light during collection and handling of the semen.

Blood riboflavin levels were not elevated, and other bulls under the same conditions of husbandry produced normal semen; it is thus unlikely that the colour of the semen is influenced by diet. The evidence strongly suggests that the characteristic is hereditary and that it behaves as a Mendelian dominant. In view of the blood analysis, the general tissues of these bulls are unlikely to synthesize the flavins. It seems more likely that we may be dealing with a genetic mutation in which the accessory organs, probably the seminal vesicles, have the specific ability to make, or more likely to concentrate, riboflavin and other flavins.

When added to white ejaculates at a concentration of 20 μgm./ml., riboflavin usually halved the uptake of oxygen and decreased the longevity of the spermatozoa. The possibility that this is due to the formation of hydrogen peroxide is being investigated. full report of this work will appear elsewhere.

Thanks are due to Prof. C. W. Emmens for h interest and advice, to Mauri Bros. and Thompson fc the use of laboratory facilities and to Roche Produc Pty., Ltd., for gifts of chemicals. We are also indebte to the Camden Park Estate, Mr. B. Doyle, Mr. Martin, Mr. R. Hayman and Dr. James for makin bull semen available or for checking its colour.

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Dissociation of Serological Complexes of Ovalbumin and Hæmoglobin using Aqueous Carbon Dioxide

In connexion with work on the fractionation o proteins by specific immunochemical methods, th dissociation of antigen–antibody complexes has bee studied. The aim was to effect this dissociation b less drastic methods than those used hitherto fo obtaining antibody[1] and if possible to isolate antige free from antibody.

Mitz[2] showed that carbon dioxide increased th solubility of some proteins in salt-free water, and thi work prompted our attempt to dissociate serologica complexes with the same reagent. The procedure me with some success when applied to ovalbumin/rabbi antibody and to horse hæmoglobin/rabbit antibod systems.

Our first experiments involved the specific precipitate of ovalbumin and its antiserum prepared in th rabbit by a short term (4 weeks) immunizing procedure. The precipitate, washed free of salt, wa soluble in aqueous carbon dioxide (0·035 *M*; *p*H 5·0 and partial dissociation of the complex was show by sedimentation analysis; two boundaries (Fig. 1*a* resolved with $S_{20,w} \simeq 5$ and 13. The slower boundar corresponded to immune globulin, the unsuppresse 'primary charge effect'[3] being mainly responsible fo the low S_{20}. Control runs using rabbit γ_2-globulin showed that the S_{20} was reduced from 6·56 S. (*I* 0·1 veronal buffer *p*H 8·6) to 5·1 S. in aqueous carbo dioxide. Different batches of precipitate produce similar sedimentation patterns although the S_{20} value were subject to some fluctuations. The pattern were not markedly altered by variation in the age o the complex, or in the temperature (3–36° C.) or ag (2 hr. to 7 days) of the solution. In contrast, significant shifts in the equilibrium, resulting in a smalle globulin release, an increase in S_{20} of the comple and finally in precipitation, were observed when th carbon dioxide concentration was decreased t 0·01 *M* or sodium chloride was added to a concentration of about 9×10^{-3} *M*.

Free antibody (15–25 per cent) was isolated fro this system by differential ultracentrifugation in

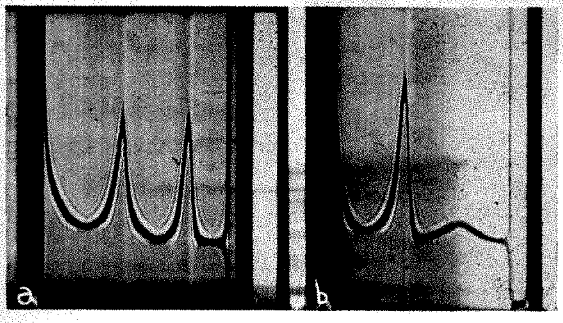

Fig. 1. Schlieren photographs from the 'Spinco' Model *E* ultracentrifuge. Solvent: aqueous carbon dioxide (0·035 *M*, *p*H 5·0). Speed 59,780 rev./min. Sedimentation from right to left. (*a*) Partially dissociated ovalbumin – rabbit antiserum complex. Initial *C* = 1·0 per cent w/v. Exposure after 34 min. at full speed. (*b*) Dissociated horse hæmoglobin – rabbit antiserum complex. Initial *C* = 0·85 per cent w/v. Exposure after 101 min. at full speed

bucket rotor ('Spinco' *SW* 39) at 150,000*g* for 6 hr. Attempts to increase the yield by reworking the deposits were increasingly penalized by the formation of complexes with reduced S_{20} values as more antibody was removed.

The isolated globulin showed no evidence of heterogeneity on sedimentation and electrophoresis, and the absence of antigen was confirmed by observation on antibody dissociated from a complex of ovalbumin labelled with fluorescein. In veronal buffer (*I* 0·1, *p*H 8·6) it had an S_{20} (6·56 S.; $C = 0·3$ per cent) and an electrophoretic mobility ($-1·2 \times 10^{-5}$ cm.^{2} V.$^{-1}$ sec.$^{-1}$) similar to those for normal rabbit γ_2-globulin. Its serological properties appeared to be unimpaired; at least 90 per cent was precipitable by ovalbumin and the characteristics of the precipitin curve were similar to those obtained for the original antiserum.

The work was extended to a specific precipitate of horse hæmoglobin and its rabbit antiserum prepared by a short-term immunization[5]. Once more the precipitate was readily soluble in aqueous carbon dioxide (0·035 *M*), but here a complete dissociation of complex occurred.

Sedimentation analysis of this solution (Fig. 1*b*) showed a major boundary corresponding with free immune globulin and a minor boundary ($S_{20} \simeq 2$) which corresponded with horse hæmoglobin when run under these conditions. The absorption of light (546 mμ) was clearly associated with the minor boundary, but of greater significance was the uniformity of absorption over the major boundary, which indicated that complete dissociation of the complex had been achieved. No hæmoglobin complex appears to exist at *p*H 5·0 in aqueous carbon dioxide, whereas the existence of complexes in solution was demonstrated by sedimentation analysis of specific precipitate dissolved in veronal buffer (*I* 0·001, *p*H 8·3). Here a broad boundary ($S_{20} \simeq 29$) and a trace of globulin were observed but no peak corresponding with hæmoglobin. The light absorption by hæmoglobin was only detectable in the main peak and thus the hæmoglobin was presumably fully complexed.

A cation-exchange cellulose (*CM*)[6] was used instead of the ultracentrifuge to separate the two components of this system, and antibody was isolated in good yield. Aqueous carbon dioxide (0·035 *M*) was used to equilibrate the cellulose column, for the application of the complex and in the development of the chromatogram. Afterwards, antibody was eluted with phosphate-saline buffer (*I* 0·044, *p*H 7·1) in 85 per cent yield while hæmoglobin remained strongly adsorbed. The eluted protein was identical with γ-globulin on paper electrophoresis and in sedimentation analysis, and the absence of hæmoglobin was confirmed by measurements of light at 410 mμ. The product contained at least 55 per cent precipitable antibody despite the susceptibility of the original hæmoglobin system to the formation of soluble complexes. Furthermore, 75 per cent of the added antigen was found in the equivalence zone precipitate in contrast to the low hæmoglobin recoveries (about 18 per cent) in precipitates from the original antiserum.

The work has been extended to the following systems: a polysaccharide[7] from *Shigella dysenteriae*/rabbit antiserum to the homologous *O* somatic antigen, horse serum albumin/rabbit antiserum to horse serum, and diphtheria toxin/horse antitoxin. These specific precipitates dissolved in aqueous carbon dioxide and preliminary examination in the ultracentrifuge indicated that some γ-globulin was released.

The solution and partial dissociation of the ovalbumin complex is not specific to aqueous carbon dioxide. It can be effected to varying extent with many organic and inorganic acids at *p*H 5, and even in the *p*H range 7–8, providing the ionic strength of the solution is low. At present, however, aqueous carbon dioxide appears to be the most advantageous method, and one of the mildest yet reported for dissociating some serological complexes. A full account of this work will be given elsewhere.

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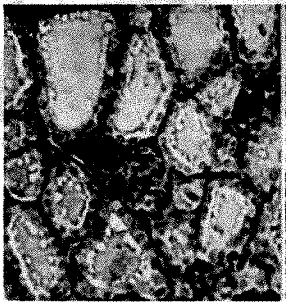
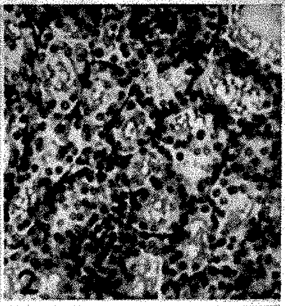
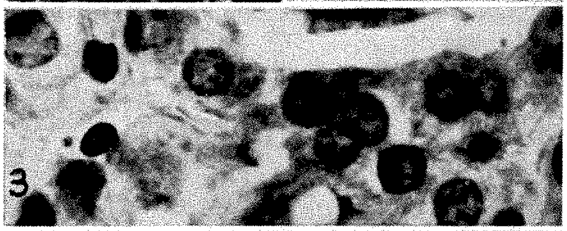
Effect of Benzene on Rat Thyroid

IN previous investigations on the anterior pituitary of rats intoxicated with benzene we found histochemical changes suggesting an increased hormone secretion from both the acidophil cells and the beta cells[1]. Since the beta cells are believed to be concerned in the rat with the secretion of thyrotrophic hormone and are therefore also called thyrotrophs[2,3], it seemed of interest to determine whether the hyperfunction of the pituitary beta cells is paralleled by cytological signs of augmented activity in their target gland, the thyroid.

Fourteen male Wistar rats, weighing on an average 260 gm., were given daily subcutaneous injections of 1 ml./kgm. body-weight of a solution containing equal parts (v/v) of benzene and olive oil. Four animals receiving only olive oil served as controls. All rats were killed by gas on the morning following the twenty-second injection. The thyroids were fixed in Helly's fluid and embedded in paraffin.







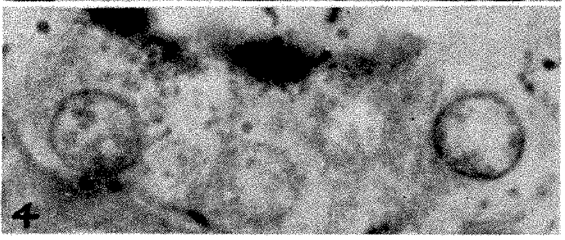


Fig. 1. Normal rat thyroid (hæmatoxylin–eosin). (× 160)

Fig. 2. Treated rat thyroid (hæmatoxylin–eosin). (× 160)

Fig. 3. Showing the cytoplasmic chromidial substance in treated rat thyroid (toluidine blue). (× 1,200)

Fig. 4. Colloid droplets at the apical pole of follicular cells in treated rat thyroid (periodic acid–Schiff). (× 2,000)

Sections were cut at 5μ thickness and stained by one of the following techniques : hæmatoxylin–eosin, methyl green–pyronin, Feulgen reaction, toluidine blue, periodic acid–Schiff reagent.

A series of morphological alterations has been consistently found in all the thyroids of the rats intoxicated with benzene. Most follicles show a much smaller size than those of control rats (Figs. 1 and 2). The follicular cells are high and columnar in shape, their nuclei appear vesicular and weakly stained by Feulgen, and the cytoplasm contains an increased quantity of chromidial substance (ergastoplasm) (Fig. 3), which is apparently related to the capacity of the thyroid cells to synthesize proteins[4,5]. Variable numbers of colloid droplets are clearly demonstrated in the cytoplasm of the follicular cells with the periodic acid–Schiff reaction : they are extremely abundant in some cells and very infrequent in others, while in some cells colloid droplets can be seen only at the apical or at the basal pole (Fig. 4). The colloid accumulated in the lumen of the follicles shows more numerous and larger vacuoles than in control rats, and is generally less intensely stainable (Figs. 1 and 2). Interspersed among the follicular cells lie many parafollicular cells, containing a scanty amount of chromidial substance (Fig. 3) and only few colloid droplets. The interfollicular cells are also abundant (Fig. 2).

Our findings resemble very closely the structural changes which occur in the thyroid when the gland is stimulated[4,5]. Therefore, it seems that under our experimental conditions benzene intoxication causes an increase in the secretory activity of the rat thyroid.

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Separation and Isolation of Fractions of Rabbit Gamma-Globulin containing the Antibody and Antigenic Combining Sites

SOME years ago[1] the digestion of rabbit anti-ovalbumin with papain powder was investigated, and it was found that a fragment could be obtained which would no longer form a precipitate with ovalbumin but which would specifically inhibit the precipitation of ovalbumin with undigested antiserum. This fragment, which presumably contained an antibody-combining site, was believed to have a molecular weight of 40–50,000, or about one-quarter that of the original γ-globulin. Earlier, Peterman[2] had shown by ultracentrifuge studies that digestion of human γ-globulin with crude bromelin and papain produced fragments of one-half to one-quarter the size of the original molecule.

In both cases large amounts of crude enzymes were used (50–100 per cent of the weight of the substrate) and consequently investigation of the digestion products was confused by the presence of substantial amounts of non-γ-globulin protein. We therefore decided to repeat the digestion of rabbit γ-globulin with papain, this time using the crystalline enzyme, which can now be prepared[3] easily, and in much lower enzyme-substrate ratios. The conditions of digestion were : 100 mgm. rabbit γ-globulin and 1 mgm. crystalline mercury papain in 3 ml. buffer, *p*H 7·0 (0·1 *M* potassium phosphate, 0·01 *M* cysteine, 0·002 *M* sodium ethylenediamine tetraacetate). This solution was incubated for 16 hr. at 37° C. The digest was dialysed with vigorous stirring and several changes of outer fluid at 2° C. More than 90 per cent of the protein was retained in the dialysis sack and

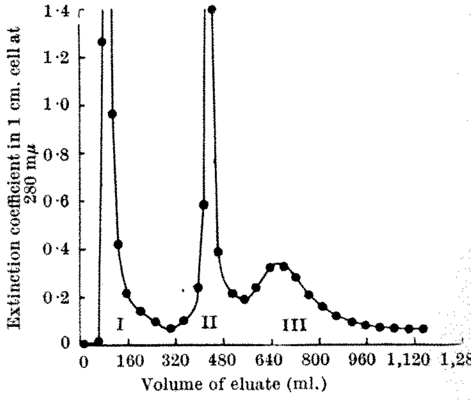
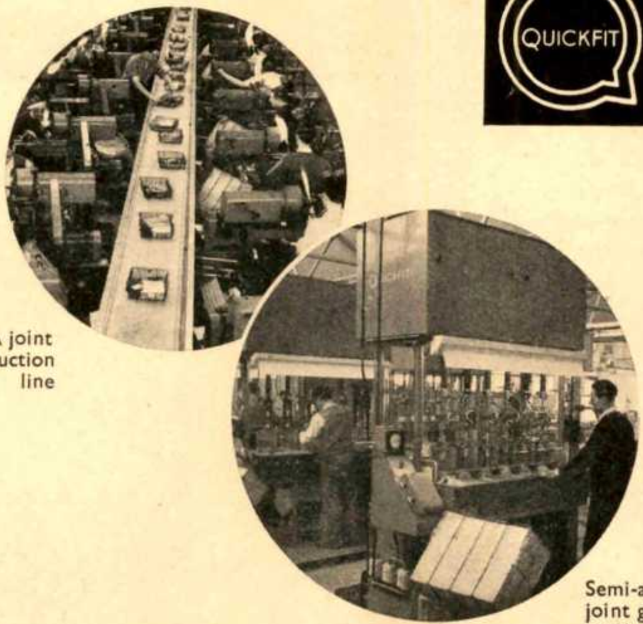


Fig. 1. Fractionation of a papain digest of rabbit γ-globulin by gradient elution on a carboxymethyl cellulose column. Sodium acetate, *p*H 5·5, gradient 0·01–0·9 *M*



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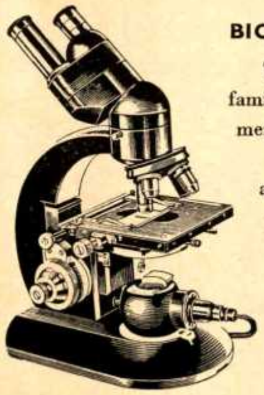

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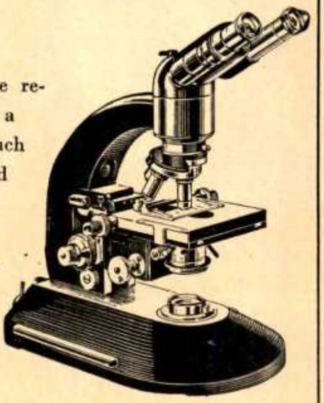

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when this material was examined in the ultracentrifuge it showed only a single component with $S_{20,w} = 3{\cdot}5$. No effective resolution could be obtained by electrophoresis but on chromatography on carboxymethyl cellulose[4], using gradient elution with an acetate buffer at *p*H 5·5, three components were separated in approximately equal amounts (Fig. 1). Preliminary estimation of the molecular weights of these components by Dr. P. A. Charlwood using the Archibald procedure[5] gave values of 55–60,000. It would thus appear that the rabbit γ-globulin is split into thirds with very little production of small fragments.

If the γ-globulin contained anti-ovalbumin, anti-bovine serum albumin (B.S.A.) or anti-human serum albumin (H.S.A.) fractions I and II specifically inhibited the combination of the same antigen and undigested antiserum, but had no activity in a heterologous system. Thus a digest of anti-human serum albumin γ-globulin will inhibit the human serum albumin – anti-human serum albumin reaction but has no influence on the bovine serum albumin – anti-bovine serum albumin system (Fig. 2). If the γ-globulin contained anti-pneumococcus polysaccharide type 3 or did not contain any known antibody then these fractions had no activity. The negative result with the polysaccharide antibody may imply a basically different structure to anti-protein antibodies but it may also be a reflexion of the quite different physical character of the antigen and the type of precipitate formed. It is possible that a different technique would show that fractions I and III from an anti-polysaccharide digest also retained the power to combine specifically with the antigen.

Fraction III showed no power to combine with the homologous antigen whatever type of antibody was present in the digest. However, when the antigenic activity of the fraction was tested with a goat anti-rabbit γ-globulin serum it was found that this fraction would precipitate most and probably all the anti-γ-globulin antibody. Fractions I and II neither formed a precipitate with the anti-γ-globulin serum nor did they inhibit precipitation of whole rabbit γ-globulin with the goat anti-serum. Fraction III has a minimum solubility between *p*H 5 and 7·5 and may be readily crystallized and recrystallized by dialysis of an alkaline or acid solution against 0·1 *M* phosphate buffer *p*H 6·5. The crystals (Fig. 3) are diamond-shaped birefringent plates, well formed but thin and easily broken, so that fragments seem always to be present. This ease of crystallization is surprising as whole rabbit γ-globulin has never been crystallized.

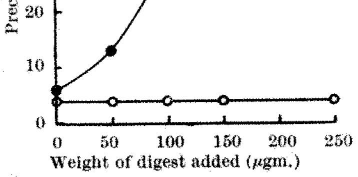

Fig. 2. Inhibition of precipitation of human serum albumin and rabbit anti-human serum albumin by a papain digest of rabbit γ-globulin containing anti-human serum albumin. ●, Precipitation time of human serum albumin – anti-human serum albumin; ○, precipitation time of bovine serum albumin – anti-bovine serum albumin

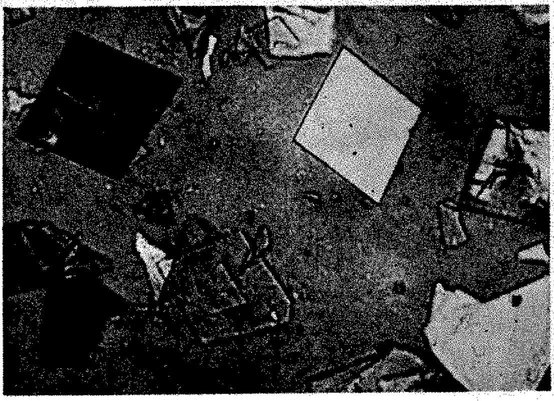

Fig. 3. Crystals of fraction III. Polarized light. (× 50)

These results suggest that the γ-globulin molecule may be made up of three parts; one of these (my crystalline fraction III) is identical in all γ-globulins molecules and is responsible for the common antigenic specificity of γ-globulins observed by Treffers and Heidelberger (see Treffers[6]). The other two parts (fractions I and III) presumably contain the antibody-combining centres, and are also responsible for the physical heterogeneity of γ-globulins; these parts may be expected to vary from molecule to molecule. This suggested structure of an identical section in all molecules of γ-globulins and two variable sections which contain the antibody-combining sites is very similar to the picture drawn by Pauling[7] in 1940. At that time he suggested that the flexibility of the variable sections might be a result of high proline content, but a rough comparison of the amino-acid composition of the three fractions by paper chromatography showed the proline content of each to be of the same order. We have no information on the essential feature of Pauling's theory of antibody formation, namely, that the antibody-combining sites are formed by refolding of a polypeptide chain with an identical amino-acid sequence. The N-terminal pentapeptide is the same in several rabbit antibodies[8,9] but it remains to be shown that this identity of sequence persists through the peptide chain, including the section containing the antibody-combining site.

Fuller details of this work will be published elsewhere.

I wish to thank Dr. P. A. Charlwood for studies of the three fractions with the ultracentrifuge, Dr. J. H. Humphrey for the gift of goat anti-rabbit γ-globulin serum, Mrs. O. Kennard for advice on crystallization techniques and Miss H. Morgan for her technical assistance.

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Heat, Salt and Hormones in Panting and Sweating Animals

IN hot climates sweating or panting to provide evaporative cooling are required for the survival of mammals. The loss of extracellular water is linked with cell water exchanges, renal water-saving, adjustments of salt excretion and hormone production.

Within 30 min. of the induction of sweating in normally hydrated man (7 subjects) at 41° C. there was reduction of urine flow to rates below 0·3 ml./min. and reduction in the rates of excretion of sodium below 20 μequiv./min. This was associated with a fall in the sodium/potassium in the urine (Fig. 1*A*). During a period of sweating at the rate of 430–500 ml./hr. conservation of sodium and water ran parallel, as a renal compensation for salt lost in sweat[1]. Ten times the resting amount of aldosterone-like activity appeared in the urine during heating, and this probably accounts for the sodium retention[2] (see also Weiner, J. S., 1st Bioclimatological Cong., Int. Soc. Bioclimatology and Biometeorology, Vienna, September 23–27, 1957; Abstract).

When sheep were studied in a similar hot environment a different pattern emerged. Romney sheep exposed to 41° C. for 4 hr. showed a prompt fall of urine flow on heating. As the respiratory-rate increased for evaporative cooling there was a progressive increase in excretion of sodium and the ratio sodium/potassium rose (Fig. 2). No aldosterone activity was detected in the urine. When sheep were later provided with water to replace that evaporated, the excretion of sodium ceased and there was reversion to a low ratio sodium/potassium in the urine (Fig. 1*B*). Excretion of potassium declined regularly from 200 to 50 μequiv./min. during the period of heating while sodium moved in the opposite direction. Sheep excrete sodium by day more than by night, but the diurnal excretion of sodium is not reversed by heating. The elimination of sodium is presumably a homœostatic compensation for the distillation of water from the respiratory tract. Sheep appear to have no effective sweat glands and are not known to lose electrolytes through the skin during evaporative cooling. Merino sheep were more variable in their responses than Romneys, but followed the same course.

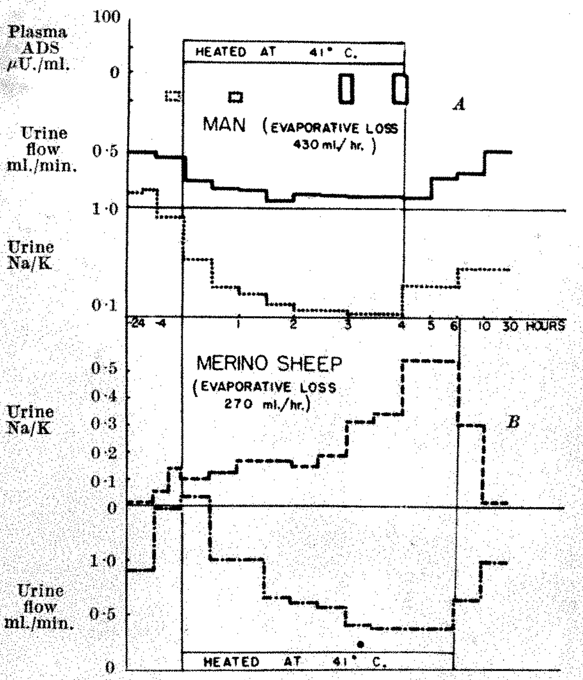

Fig. 1. *A*. Effect of heating at 41° C. on urinary flow and the ratio sodium/potassium in man. The urine flow reached 0·20 ml./min. before antidiuretic substance (ADS) appeared in the plasma. Sodium excretion fell during heating and sweating. *B*, In Merino sheep urinary flow fell on heating but the ratio sodium/potassium and excretion of sodium increased. There was a reversal of the ratio sodium/potassium as cooling took place

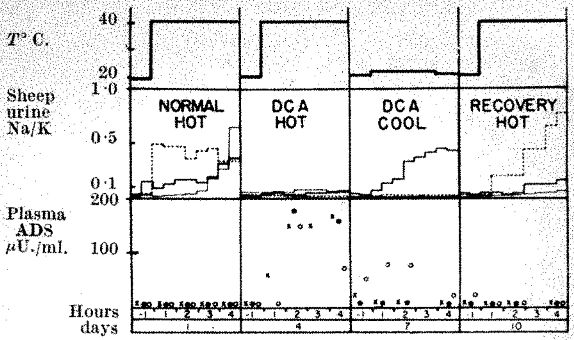

Fig. 2. Romney sheep (3) heated for 4 hr. at 41° C. in winter. No antidiuretic substance (ADS) appeared initially, but large amounts were released into the plasma after injections of deoxycortone (DCA) (0·15 mgm./kgm.). There was a low sodium excretion. Ten days later sodium was excreted during heating, but there was no production of antidiuretic substance

Winter exposure to the standard heat stimulus in both man and sheep led to low rates of flow of concentrated urine (0·1–0·3 ml./min.) without the liberation of measurable quantities of antidiuretic substance into the plasma[3–5]. During summer, antidiuretic substance appeared after 2–4 hr. heating at 41° C. The possibility that salt-active adrenal steroids might regulate the transfer of water and thus the release of antidiuretic substance was tested by exposing three Romney ewes to the standard hot environment in winter, when no antidiuretic substance normally appeared. The ewes were then injected intramuscularly with 15–20 mgm. of deoxycortone and heated for 4 hr. (Fig. 2). Little urinary sodium was excreted but antidiuretic substance appeared in the plasma on heating. As the effects of the hormone wore off the amount of antidiuretic substance appearing at 41° C. was reduced and after 10 days there was virtually no residual activity. In ten Merino sheep it was necessary to heat for 4 hr. at 44° C. to induce a release of antidiuretic substance in summer. When deoxycortone was injected into Merinos the release of antidiuretic substance persisted longer than in Romneys. Winter production of antidiuretic substance in the heat was achieved by injection of this salt-active hormone in both breeds.

In seeking the mechanism of this action of deoxycortone, estimates were made of the plasma volume and extracellular volume of man and sheep subjected to heat[6]. During winter when no antidiuretic substance appeared in the plasma of four men there was no decrease in the *T*1824 space and less than 1 l. loss of thiocyanate space after 4 hr. heating with the loss of 2·5–3·5 kgm. of sweat. Sheep heated for 4–6 hr., with the loss of 1·0–2·0 kgm. of water by evaporation showed less than 10 per cent change in the plasma volume in winter when antidiuretic substance did not appear. In summer, or when deoxycortone was given, there was a reduction in plasma and interstitial volume during heating and antidiuretic substance was detected in the blood. In the monkey, Sweet *et al.*[7] report an increase of the inulin space on treatment with deoxycortone and in sheep during summer we have found a 25 per cent expansion of the thiocyanate space relative to winter. This would not prevent plasma concentration from occurring if cell permeability to water were affected by the deoxycortone.

It appears that there is a difference between the summer and winter availability of tissue water in both man and sheep. In winter, extracellular water may be mobilized from other sources but not so easily as in summer. Simulation of summer responses to water loss was achieved by injections of deoxycortone. On the other hand, sodium retention in man[8] and excretion of sodium in sheep during heating at any time of the year means that salt-active hormones cannot be effective during the period of heating in both animals. Yet sheep heated in winter mobilize fluid to replenish the plasma space, thus preventing the relative plasma concentration associated with the release of antidiuretic substances, while sodium continues to be excreted. The sodium-resorbing hormone appears, then, not to be the final answer to this problem.

Sodium excretion during heating is thus linked to the method of evaporative cooling. In man producing salt sweat, sodium is retained by the kidney, whereas in sheep, which pant, there is excretion of sodium. There is a seasonal change in the amount of replacement of extracellular water from other sources during heating. When plasma is concentrated, antidiuretic substance appears, and plasma concentration on heating can be induced by deoxycortone. Flow of urine may be reduced to 0·2 ml./min. without antidiuretic substance being detectable in the plasma.

The financial assistance of the Wool Trust Fund and the National Health and Medical Research Council of Australia is gratefully acknowledged.

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Correlation between the Fat and the Protein Content of Human Milk

I HAVE undertaken a study of the chemical composition of mature human milk (excluding colostrum) in the Kivu region of the Belgian Congo. The analyses were done on 250 samples of all the milk secreted during 24 hr. by mothers belonging to the Bashi tribe. This ethnic group lives along the eastern shore of Lake Kivu (about long. 29° E. of Greenwich) in the Belgian Congo, between latitudes 2° 10′ S. and 2° 40′ S. at an altitude varying from 1,460 to 2,000 metres above sea-level. Their staple foods are beans, sweet potatoes and beer made from bananas. Demaeyer took the samples in his quantitative study of milk secretion.

I found the mean caloric value, the protein-, fat- and ash-content of the milk from African mothers in the Kivu to be lower, and its lactose-content to be higher (although no statistical analysis of the difference between the means was possible), than the corresponding averages calculated by Macy *et al.*[1] from most literature reports on the composition of human milk and dealing mainly with European and American women.

The observation that both the fat and the protein in human milk are lower here than in other regions with higher dietary standards led us to examine the relation between the fat- and the protein-content of the milk from the mothers here.

A very strong positive correlation was found between the 'protein' (total nitrogen × 5·12)-content and the fat-content of the milk ($n = 224$, $r = 0{\cdot}4426$, $P < 0{\cdot}001$).

This means that for this region a milk sample with a low fat-content tends to have also a low 'protein'-content, that the fat-content of the milk and the 'protein'-content of the milk rise together, and that a milk sample with a high fat-content tends to have at the same time a high 'protein'-content. As far as we know, this correlation has not been observed before in human milk, and we think that it would be important if some of the workers in this field would examine their results in this light, to see whether the same correlation is observed elsewhere, with mothers having a completely different diet. It cannot be calculated from the literature on the subject because only mean values for the various components are published and not the analyses of individual samples. This observation may help towards a better understanding of the relation between the diet of the mothers and the nutritive value of their milk, and perhaps even of the mechanism of the milk secretion in the mammary gland. Breirem[2], in his review of the literature on the relation between the nutritional value of cow's milk and the nutrition of the animal, reports that Møllgaard and Lund, Steensberg, Kay, Breirem and Saarinen have observed that deficiency of energy and/or protein in the diet of the cow will reduce both the fat- and protein-content of the milk. Janz *et al.*[3] report a similar observation made by Escudero and Pierangeli for human milk; these authors reported that mothers with a diet rich in proteins secreted milk with a high protein- and fat-content.

These reports give indirect circumstantial evidence for the existence of this positive correlation between the fat- and protein-content of milk observed so clearly in my work.

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Effect of Various Natural Steroids on the Phagocytic Activity of the Reticulo-Endothelial System

It was initially observed by Nicol[1] that, following the administration of œstrogenic hormones, there was stimulation of the activity of phagocytic cells in the endometrium. This work was extended later to include both natural and synthetic œstrogens[2-4], and these findings indicated that in both male and female animals œstrogens possess a strong stimulating influence on the reticulo-endothelial system, which results in the appearance of large numbers of macrophages in the spleen, liver and lymph nodes, and the mobilization of these macrophages into the circulation. In the above researches, the trypan blue method was used to assess the activity of the reticulo-endothelial phagocytes. These results have since been confirmed by the carbon method, and it has been found that the strongest stimulants of the reticulo-endothelial system possess high œstrogenicity[5,6].

The following investigation was planned to ascertain the effect of various œstrogenic and non-œstrogenic natural steroids on the phagocytic activity of the reticulo-endothelial system.

The present experiments were carried out on 105 male white mice (*T.O.* Swiss strain) of 20–30 gm. body-weight. Five of the animals were used for assessing the effect of each compound on the phagocytic activity of the reticulo-endothelial system, each animal receiving one subcutaneous injection of 0·5 mgm. of each steroid in 0·05 ml. of arachis oil daily for six days. The phagocytic activity was then measured on the eighth day by the rate of disappearance of a known amount of carbon from the circulating blood[7], the procedure being as follows. Each animal was given one intravenous injection of carbon of particle size 250 A., the dose of the carbon being calculated on the basis of 16 mgm. per 100 gm. body-weight. Blood was then taken at short intervals during the first 60 min. following the injection, and the concentration of the carbon in each blood sample was measured by means of an absorptiometer. The logarithmic values of the absorptiometer readings lie along a straight line when plotted against time, and the slope of this line has been taken as the measure of total body phagocytic activity or the phagocytic index, which is denoted in the present communication by the symbol K.

Twenty-five of the animals were used as controls. Each received one subcutaneous injection of 0·05 ml. arachis oil daily for six days and then showed an average phagocytic index or K-value of 13 ± 2·4, the carbon completely disappearing from the blood in about 100 min.

Table 1 shows the K-values of the various natural steroids together with their relative standard deviations. These results show that the phagocytosis of particulate carbon may be modified by natural steroids. The œstrogenic steroids caused rapid removal of the carbon from the blood-stream due to stimulation of reticulo-endothelial activity. Progesterone caused very slight stimulation of the reticulo-endothelial phagocytes. Cortisone caused marked depression of phagocytic activity, thus providing further confirmation of our previous reports of experiments involving the method of *intravitam* staining with trypan blue[8]. Testosterone and cholesterol and the other steroids shown in Table 1 had little or no effect.

Table 1. EFFECT OF VARIOUS NATURAL STEROIDS ON THE PHAGOCYTIC ACTIVITY OF THE RETICULO-ENDOTHELIAL SYSTEM

Steroid used	Phagocytic index (K-value)
Œstradiol benzoate	81 ± 15
Equilin	77 ± 24
α-Ethinyl œstradiol	75 ± 8·9
Œstrone	65 ± 11
Equilenin	51 ± 8·2
Œstriol	47 ± 9·8
Progesterone	17 ± 2·5
Ethisterone	14 ± 1·7
Testosterone	13 ± 1·1
Cholesterol	11 ± 2·5
Lanosterol	11 ± 1·7
Ergosterol	10 ± 1·9
Androstalone	10 ± 1·3
Sitosterol	10 ± 1·1
Deoxycortone acetate	10 ± 2·2
Cortisone	7 ± 0·9
Control values for 25 animals	13 ± 2·4

It is thus evident that the phagocytic activity of the reticulo-endothelial system is modified by hormones, and that the steroids possessing the power of inducing œstrus also induce stimulation of macrophage activity. Œstradiol benzoate has been found to be the most powerful of the natural œstrogens and gives a phagocytic index or K-value of 81 ± 15, the carbon disappearing completely from the blood in about 15 min. compared with 100 min. in the controls; cortisone acetate was again the major depressant, the circulating blood not being clear of carbon for about 2 hr. after the injection.

We are indebted to Dr. W. J. Tindall, of Organon, Ltd., who kindly supplied the majority of the steroids.

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Action of Beta Radiation on the *Proteus P*18 Bacillus

We have grown the *Proteus P*18 bacillus at 37° C. in an ordinary medium containing 20 per cent horse serum and varying amounts of radioactive phosphorus. With a dose of 4 μc. of phosphorus-32 per 100 ml. of medium the multiplication and microscopic appearance of the bacilli are scarcely altered. When the concentration of phosphorus-32 is raised to 8 μc. per 100 ml., growth is slowed down and a series of important morphological transformations can be observed.

Between 4 and 6 hr. after inoculation, besides the normal *Proteus* bacilli, filaments 20–80μ in length, that show rapid creeping movements, appear (Fig. 1*b*). After 6–8 hr., filaments with a globular formation at one end are observed (Fig. 1*c*); these move very fast, the globule foremost. After about 8–10 hr.

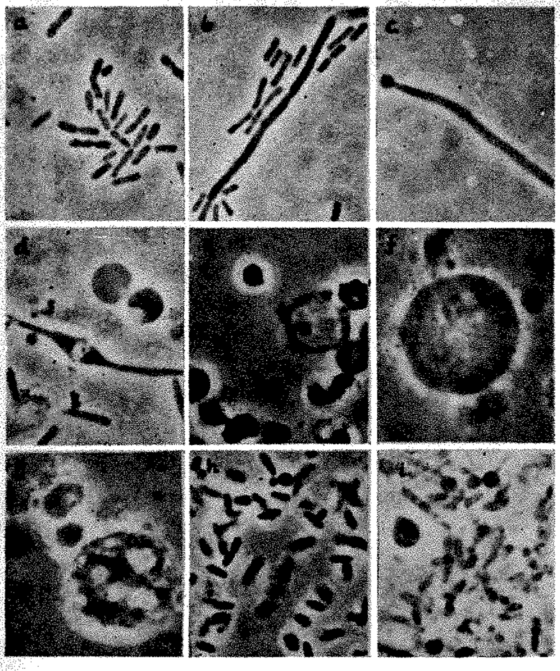

Fig. 1. Morphological changes of *Proteus P*18 under the influence of radiation from phosphorus-32. (*a*) Normal *Proteus* ; (1*b*–1*i*) see text

numerous dark globular elements 1–8μ in diameter are seen, as well as filaments with a median bulge (Fig. 1*d*). At the same time the normal bacilli become rare and the long filaments are very numerous. Certain globular formations have a small, very thin and spindly appendage in a spiral (Fig. 1*e*). After 15 hr. bright globular elements 8μ in diameter and small particles at the limit of visibility appear. After about 21 hr. the culture contains scarcely anything but dark or bright globular formations, 30–40μ in diameter, with black granulations or vacuoles (Figs. 1*f* and *g*). The small particles at the limit of visibility are very numerous ; but we were unable to photograph them. When the culture is prolonged, the globular formations become fewer and are replaced by a considerable number of small particles. After about 31 hr. there is a regression, and both short and long filaments and many thick rods appear ; some of the long filaments have a median bulge. Finally, after 48 hr., one finds normal bacilli again (Fig. 1*h*).

If a 21-hr. culture made in the presence of 8 μc. of phosphorus-32 and rich in globular formations is re-inoculated into a medium containing the same quantity of radioactive phosphorus, one obtains almost exclusively globular formations. A second transplantation under the same conditions after 24 hr. also shows many whole or destroyed globular formations, but mostly rods and short filaments. At the third transplantation the globular formations disappear almost completely and the culture consists of long filaments, rods and normal bacilli. Still more transplantation in the presence of phosphorus-32 produces a more and more normal culture, containing only a few filaments or globular formations.

When *Proteus P*18 develops in a medium containing 16 μc. of phosphorus-32 per 100 ml. of medium, similar changes are observed but they occur slightly faster (Fig. 1*i*).

At a dose of 28 or 40 μc., beside the normal bacilli, one finds a few short filaments and globular formations after 6–9 hr., but neither long filaments nor large globular formations are observable. Apparently the morphological changes are very short-lived and incomplete and the culture quickly reverts to normal. Of course, the larger doses slow down the microbial growth very noticeably ; this ceases after about 12 hr.

The transformations which we have described suggest in many respects the *L* forms produced in the presence of penicillin[1,2] by X-rays[3].

The interesting aspect of our experiments is the shortening of the period of unusual morphology when high doses of phosphorus-32 are used, and the reversion to normal forms in spite of the continuous action of radiation. An adaptation to the beta-radiation of phosphorus-32 therefore seems likely.

The metabolism of the bacterial forms produced by phosphorus-32 and its action on other bacilli are under investigation.

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Autonomic Functions of the Hippocampus

AT present no definite function can be attributed to the hippocampus. In the cat and the dog, electrical stimulation of the fimbria, the main efferent tract from the hippocampus, has been reported to give rise to no detectable autonomic changes[1], although it is well known that stimulation of other components of the limbic system can elicit autonomic changes.

In rabbits anæsthetized with urethane, pentobarbital sodium or ether, it can be shown that stimulation within the ventral part of the fimbria raises the blood pressure and increases the rate and amplitude of the respiration as illustrated in Fig. 1. Stimulation within the more dorsal part of the fimbria depresses the blood pressure, but has similar effects on the respiration as shown in Fig. 2. The effects obtained from these two regions of the fimbria are qualitatively reproducible in many animals, but vary quantitatively from animal to animal.

Degenerating fibres are being traced by a modified Nauta–Gygax method[2] from lesions made in the fimbria in positions which gave a definite pressor or depressor response when stimulated. In one rat studied by Nauta[3], destruction of the caudal half of the hippocampus led to degeneration of fibres coursing through the middle and ventral parts of the fimbria, some of which continued as the medial cortico-hypothalamic tract to the periventricular zone of the anterior hypothalamus, a region which raises the blood pressure when stimulated. The fimbria is also known to contain fibres terminating in the septum and in the medial mammillary nucleus, both of which give depressor responses when stimulated (Cragg and Hamlyn, unpublished work). It is

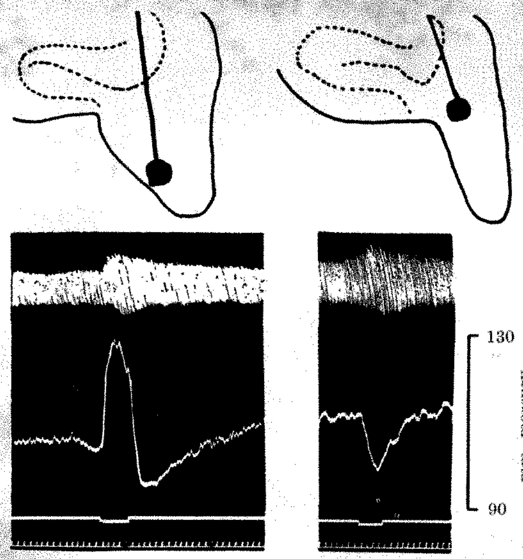

Fig. 1 Fig. 2

Figs. 1 and 2. The changes of respiration and blood pressure produced by stimulation of the fimbria at the positions indicated. Rabbits anæsthetized with urethane and ether. Time marker: 5 sec.

therefore possible that one of the functions of the hippocampus is concerned with the regulation of some of the activities of the autonomic nervous system.

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Semipermeability of the Nuclear Membrane

Previous studies on the osmotic properties of isolated nuclei indicated that ions or molecules of low molecular weight readily penetrate the nuclear membrane. Of the components tested, only protein and certain other substances of high molecular weight were found to exert an osmotic effect[1,2]. The process of isolation may have marked effects on the properties of the nucleus and its membrane. In the present studies, osmotic properties of the nucleus were studied by micro-injection of certain solutions into the cytoplasm. Relatively small, unpigmented oocytes of *Rana pipiens* were used. Photographic records were obtained and all measurements were made from these. No harmful effects were observed within the cells following injection.

In some of the experiments a high molecular weight synthetic polymer, polyvinylpyrrolidone, was used (kindly supplied by Antara Chemicals, General Aniline and Film Corporation, Philadelphia). This substance, which has been used as a blood substitute, has the advantage of being non-toxic, relatively non-reactive, and of known molecular weight. The polymer was dissolved in a solution of potassium and sodium chlorides. For experiments in which potassium and sodium chlorides alone were used, the solution consisted of nine parts 0·126 *M* potassium chloride and one part 0·123 *M* sodium chloride. For the other solutions the concentrations of potassium and sodium chlorides were adjusted slightly so that all solutions had exactly the same tonicity with respect to the cell membrane (isosmotic with amphibian Ringer). The *p*H, in each case, was adjusted to approximately 6·5.

For each solution a series of about ten experiments was performed. The results indicate clearly that polyvinylpyrrolidone has an effect on nuclear volume. The injection of 0·5 per cent of the polymer causes a significant increase in volume of the nucleus, whereas 2·0 per cent or 4 per cent causes a significant decrease. 1 per cent and 1·5 per cent polyvinylpyrrolidone have very little effect on nuclear volume. If we assume that the observed volume changes are osmotic in nature, then nuclear volume is apparently dependent on the colloid osmotic pressure of the cytoplasm. Furthermore, we can conclude that the isotonic concentration of polyvinylpyrrolidone lies in the range 1–1·5 per cent. The molecular weight of this preparation of polyvinylpyrrolidone (type *NP*–K30) is reported by the manufacturer to be 40,000, and the molar concentration for the isotonic solution is therefore equal to $2 \cdot 5 - 3 \cdot 75 \times 10^{-4}$ *M*. In further experiments crystalline bovine serum albumin (molecular weight, 65,360)[3] was used. A 1·96 per cent (3×10^{-4} *M*) solution of albumin was found to cause no significant change in volume of the nucleus. An albumin solution of twice that concentration, however, caused a significant decrease in volume. Injection of a solution of potassium chloride and sodium chloride alone, which is isotonic with respect to the cell membrane (isosmotic with amphibian Ringer), as well as a solution 20 per cent more concentrated, invariably caused an increase in nuclear volume. It might be re-emphasized that the potassium chloride–sodium chloride solutions of polyvinylpyrrolidone and albumin which are hypertonic for the nucleus are isotonic with respect to the cell membrane.

These results would indicate that the nuclear membrane of the intact oocyte does not allow the free penetration of molecules of 40,000 molecular weight and larger. It is possible that some penetration does occur, but to such a small extent that it is not detectable under the experimental conditions employed. There has been no systematic attempt to determine a threshold range of molecular weight, below which the molecules would be osmotically ineffectual. Previous work with this species indicated that sucrose, with a molecular weight of 342, readily penetrates the isolated germinal vesicle nucleus, whereas egg albumin, with a molecular weight of approximately 34,500, does not[2]. On the other hand, it has been shown that blood proteins rapidly get into the nuclei of mammalian somatic cells, where they may even accumulate[4]. It would be important to show if differences exist between the nuclei of germ cells and somatic cells (or even between the same cell types of two different species) that might account for this apparent discrepancy. (See Anderson[5] for a discussion of this.) It is conceivable that active processes are involved in the passage of certain high molecular weight substances (proteins) between nucleus and cytoplasm. The presence of such an active mechanism might allow the penetration of certain large molecules through the nuclear membrane without necessarily destroying the properties of the nucleus as an osmometer. This possibility might reconcile the observations on osmotic properties of nuclei, and the apparent permeability of certain somatic cell nuclei to proteins, as has been suggested by Stern and Mirsky[6].

The work reported here was aided in part by funds from a Rockefeller grant to the Zoological Laboratory. We should like to express our sincere thanks to Prof. L. V. Heilbrunn for his advice and encouragement, and to Dr. Merkel H. Jacobs and Dr. Paul G. LeFevre for reading the manuscript.

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Kinetics of Muscular Contraction in Heavy Water

VARIOUS lines of evidence, for example, involvement of sulphydryl groups and adenosine triphosphatase, suggest that the rate-limiting process for muscular contraction may be proton transfer. In this event, one would expect the rate of either isometric or isotonic contraction to be slowed up in the presence of heavy water (D_2O). According to a recent analysis[1], which of the two most affected will depend on whether activation or production of tension is involved.

Fig. 1 shows the development of isometric tension in normal and heavy water – Ringer solution after 20 min. equilibration. The reduction in rate of just over three times is completely reversible. Maximum tension and relaxation phase were not altered; action potentials in another muscle (frog sartorius) were found to be normal. These results, with the exception of 30 per cent less tension, are reproduced by normal Ringer solution with osmotic pressure increased by addition of sucrose to 1·6 times (that is, 0·416 osmolar)

Fig. 2 shows force–velocity curves for the three cases. The isotonic rate is reduced some twelve times in heavy water – Ringer solution, while for sucrose Ringer the factor is again only three.

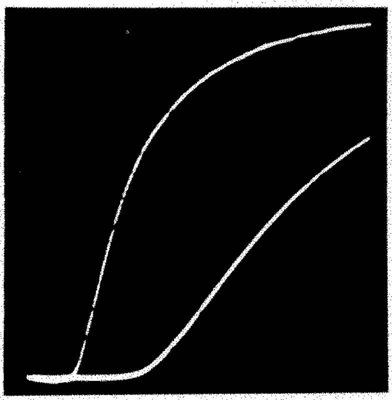

Fig. 1. Development of isometric tension in turtle (*Chrysemys picta*) retractor penis muscle at 0° C. Left to right, in normal and heavy water – Ringer solution

From this we should conclude that the reaction affected is tension production, and from the magnitude of the effect more than one (possibly three) protons are involved.

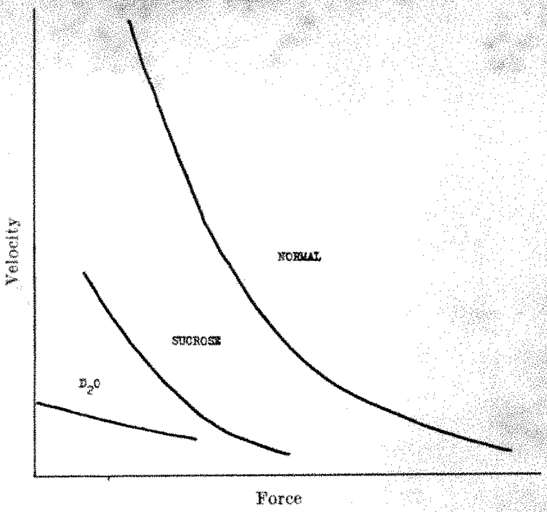

Fig. 2. Force–velocity curves of the same muscle, obtained with a continuously recording device

I am indebted to Dr. N. Geschwind for observation of action potentials by micro-electrode technique, and to the Muscular Dystrophy Associations of America for support.

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Influence of Water Deprivation on Taste Sensitivity in Man

IN a previous communication[1], I presented results showing that forced loss of salt from the body is accompanied by increases in taste sensitivity to 'salt' in human subjects. Sensitivity to 'sweet', 'sour' and 'bitter' remained unchanged. In a study of the preference behaviour of thirsty (deprived of water for 17½–19 hr.) and non-thirsty rats, Young and Falk[2] report that thirsty rats reject hypertonic solutions and tend to prefer water to hypotonic salt solutions. Thus it appears that the preference behaviour of rats deprived of water is practically the opposite of that shown by rats deficient in salt. In view of the finding that salt deficiency is accompanied by an increase in sensitivity to salt, Young and Falk's results suggest that water deprivation may be accompanied by a decrease in sensitivity to salt.

To check this, four human subjects (*H*, *R*, *J* and *C*) were rendered water-deficient and their sensitivity to 'salt' (sodium chloride) and 'sour' (sulphuric acid) was studied. Details of the procedure used to establish absolute thresholds were reported previously[1]. After rinsing the mouth, subjects were careful to spit out as much as possible of the fluid before swallowing. Nevertheless, very small amounts of fluid were undoubtedly swallowed during testing.

Throughout the control, experimental and recovery periods of the experiment (nine days for subjects *H* and *R* and eight days for subjects *J* and *C*) the overall caloric value of the food intake of all subjects was controlled. It averaged about 2,100 cal./day for *H*, about 2,650 cal./day for *R*, about 2,840 cal./day for *J* and about 2,450 cal./day for *C* (all food was weighed; nutritional values and water content were calculated from ref. 3). The proportion of protein was kept fairly constant throughout the experiment, but the proportion of carbohydrate was slightly reduced and that of fat slightly increased during the experimental period in order to keep the 'dry' diet reasonably palatable. Intake of salt was also slightly less during the experimental period. During the control period of three days for all subjects and the recovery period of three days for subjects *H* and *R* and two days for subjects *J* and *C* water was allowed *ad libitum*.

For subjects *H* and *R* the experimental period lasted from 8.30 a.m. on the fourth test day until 11.30 a.m. on the sixth test day; for subjects *J* and *C* from 9 p.m. and 6 p.m. on the third test day until 10.30 p.m. and 12 p.m. on the sixth test day, respectively. During the experimental period no fluid was taken deliberately and all food eaten was of a very low water content. Total water intake from food and oxidation over this period was 659 ml. for subject *H*, 834 ml. for *R*, 1,000 ml. for *J* and 837 ml. for *C*. Subjects *H* and *R* carried out a 2-hr. sweating session (in a hot room at 95° F. wet bulb, 105° F. dry bulb) during the morning of the first day of water deprivation. Losses in body-weight, recorded over the experimental period, were 2·500 kgm., 3·150 kgm., 2·250 kgm. and 2·900 kgm. for subjects *H*, *R*, *J*, and *C* respectively. Increases in the concentrations of sodium in the serum and chloride in the plasma and in hæmatocrit percentages also occurred in all subjects (see Table 1).

The means of thresholds for 'salt' of subjects *H* and *R*, determined daily at 9.00 a.m. and 4.45 p.m., and of subjects *J* and *C*, determined daily at 9.00 a.m. and 11.30 a.m., are presented in Fig. 1. The means of thresholds for 'sour' of subjects *H* and *R*, determined daily at 2.15 p.m., and of subjects *J* and *C*, determined daily at 2.30 p.m., are also shown in Fig. 1.

Table 1. CONCENTRATIONS OF SODIUM IN SERUM, CHLORIDE IN PLASMA AND HÆMATOCRIT PERCENTAGES FOR SUBJECTS *H*, *R*, *J* AND *C**

Day of experiment	Serum-sodium (m.equiv./l.)		Plasma chloride (m.equiv./l.)		Hæmatocrit (per cent)	
	R	*H*	*R*	*H*	*R*	*H*
3	147	147	109	112		
6	160	155	118	115	48·7	44·9
7	148	146	107	111	48·4	44·8
9	148	144	108	110	46·5	40·9
	J	*C*	*J*	*C*	*J*	*C*
3	144	137	109	104	50·1	45·1
6	147	141	111	113	51·9	46·7
8	144	141	110	108	49·2	46·1

* Thanks are due to Prof. R. A. McCance, Department of Experimental Medicine, University of Cambridge, for arranging the taking and analysis of these samples.

From these results, it can be seen that loss of body-water was accompanied by a decrease in sensitivity to 'salt', whereas sensitivity to 'sour' remained unchanged.

The results also show that sensitivity to 'salt' was less acute at 9 a.m. than at the later session on the same day. I have found evidence of similar systematic fluctuations in sensitivity to 'salt', 'sweet', 'sour' and 'bitter' solutions during the course of a day of normal food intake (to be reported elsewhere). The variations are statistically significant. The degree of variation appears to depend largely on the caloric value and composition of the food intake. Systematic variation during the day in taste sensitivity has also been reported by others, namely, Hammer ('sour'), Goetzl *et al.* ('sweet') and Irvin and Goetzl ('salt')[4]. In the present results, the degree of variation from 9 a.m. to times later in the day has not remained constant during the period of decreased sensitivity to salt. This is probably due to the fact that the tendency for sensitivity to increase from the 9 a.m. session to the later session was partly counteracted by the tendency for it to decrease due to the increasing loss of body-water over this period. It appears, then, that the factors responsible for the changes in taste

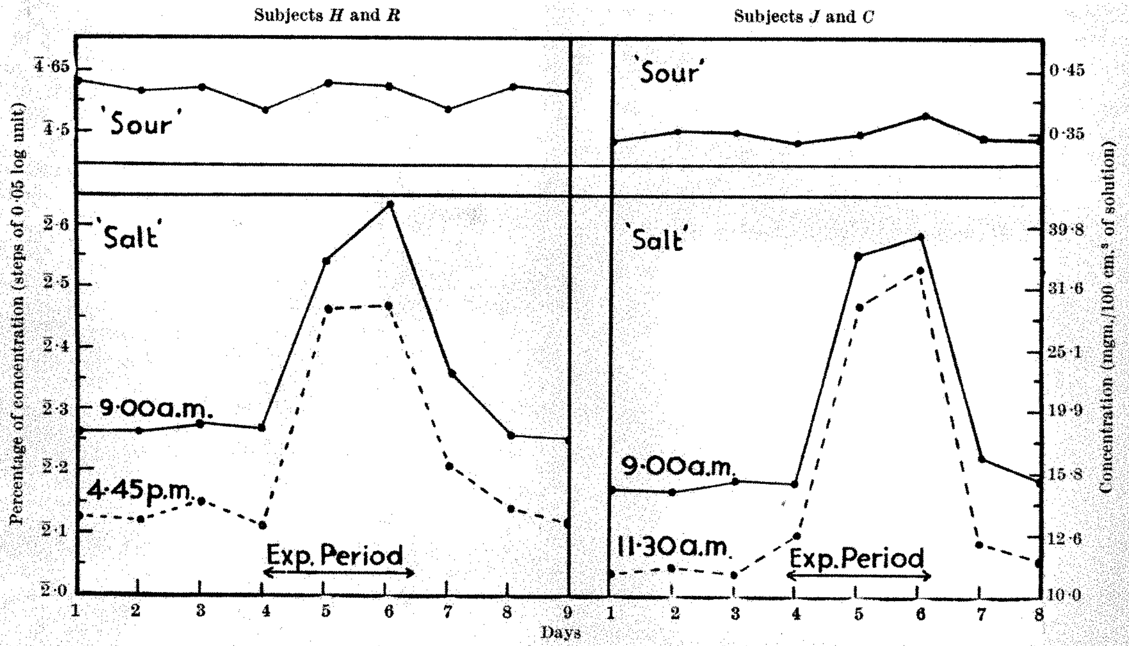

Fig. 1. Mean absolute thresholds for 'salt' and 'sour' for subjects *H* and *R* (left) and for subjects *J* and *C* (right). Each threshold is the mean of eight determinations, four from each of two subjects

sensitivity which occur during the day are independent of the factors causing the observed changes in sensitivity which were specific to 'salt'.

Since losses in body-salt, which result in a fall in the concentration of sodium in the extracellular fluid, were accompanied by increases in sensitivity to salt, and losses in body-water, which result in a rise in the concentration of sodium in the extracellular fluid, were accompanied by a decrease in sensitivity to salt, it appears likely that these changes in sensitivity are related to the concentration of sodium, and possibly the osmotic pressure, of the extracellular fluid (the osmotic pressure is usually, but not always, dependent on the concentration of sodium in the extracellular fluid). Changes in the volume *per se* of the extracellular fluid would not appear to be related to the sensitivity changes, since under both conditions reductions occurred in the volume of the extracellular fluid.

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Nitrite Accumulation in the North-East Tropical Pacific

During two oceanographic expeditions in waters off the Mexican and Central American coast, nitrite analyses were made on water samples from between the surface and 800 m. depth in order to obtain information on the decay process of planktonic material.

Because of the intermediate position of nitrite in the nitrogen cycle between ammonia and nitrate, its concentration is determined by the ratio of ammonia oxidation to nitrite oxidation, in case of nitrification. The bacteria responsible for the oxidation of ammonia do not occur freely suspended in the open ocean but are attached to plankton organisms. Dying plankton often accumulates in the thermocline, and in culture experiments large quantities of nitrite appear soon after the cultures die[1]. Many investigators have found a nitrite peak associated with the thermocline layer. In highly productive, tropical areas[2] conditions are especially favourable for a strong decay of planktonic material. As a result of this decay all 20 stations occupied 50–650 miles off the American coast from the Gulf of Panamá (4° N.) to the southern tip of Baja, California (23° N.), show this nitrite accumulation in the thermocline layer (Fig. 1).

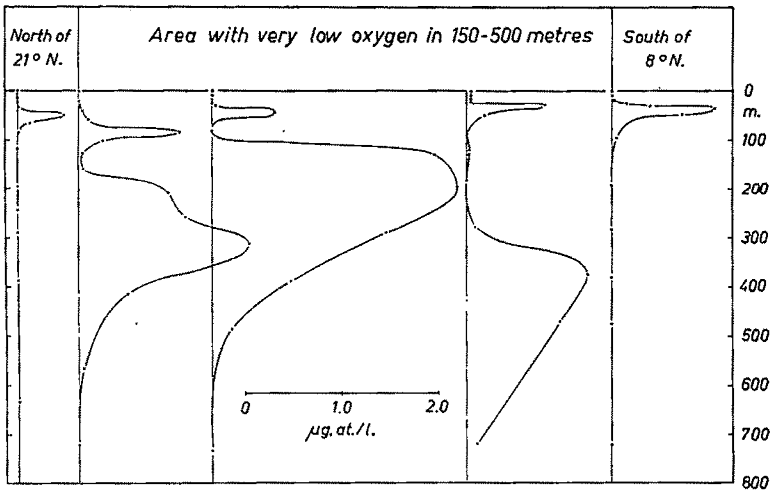

Fig. 1

Denitrifying bacteria also exist in the sea, some of which are able to reduce nitrate to nitrite under anaerobic or nearly anaerobic conditions in the presence of abundant organic matter. In most areas of tropical oceans there is, even in the oxygen minimum layer, some oxygen present. Wattenberg[3] reported 0·37 cm.^{3}/l. as the lowest oxygen value measured on the *Meteor* Expedition in the South Atlantic. Due to the weaker subsurface circulation in the Pacific and a relatively high production in its eastern part, a large body of water is found within which the oxygen content is almost zero[4]. This water of low oxygen content extends off the American coasts between 8° N. and 21° N. in an intermediate layer between 150 and 1,000 metres. Fig. 1 reveals that only the area with very low oxygen content is also a region with a second, deep nitrite maximum, with values up to 2·5 µgm. at./l. Both features, low oxygen and high nitrite concentrations, are found between 150 and 500 metres.

From an oxygen versus nitrite plot the two nitrite maxima are clearly distinguishable. Nitrite from the upper maximum is found within a wide oxygen range from about 1 to 5 cm.^{3}/l., due to the very sharp thermocline with which this maximum is associated. The nitrite values of the deep maximum occur only in water with less than 0·10 cm.^{3}/l. oxygen, which suggests that the deep nitrite maximum is produced by reduction of nitrate to nitrite. Similar observations of a deep nitrite maximum were made by Gilson[1] in the eastern Arabian Sea, but at that time could not be explained.

This work was partly supported by funds of the Inter-American Tropical Tuna Commission, Scripps Institution of Oceanography, La Jolla, California. A detailed report of this study will be published elsewhere.

Wilhelm Brandhorst

Institut für Meereskunde
der Universität Kiel. June 18.

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MUSEUMS AND ART GALLERIES AS CULTURAL CENTRES

FOR many years the Museums Association has in one way and another been pressing for some form of Government assistance to help, and even in some cases to preserve from extinction, the many small society and trustee museums in Britain. From time to time various organizations have stressed the importance and urgency of the claims of museums and art galleries and recently the Bow Group prepared a detailed memorandum on the subject*.

The main part of this report naturally surveys the facts regarding the present position of the museum and art gallery service. It is pointed out that this is complex and that the official relationships between the national and provincial institutions are thoroughly unsatisfactory. With the increasing leisure of many people and the great advances in organized education made in recent years, it is indeed imperative that museums and art galleries should be in a far better position than they are to deal with not only the preservation of their buildings and contents but also the wider problems of visual education.

The memorandum clearly indicates the complexity of organization in the museum and art gallery field, and points out that some are financed direct from the Treasury, others from the Ministry of Education, some from county or municipal rates and yet others from universities and various societies and trustees.

The fundamental aims of museums and art galleries are discussed, and in addition it is rightly stated that each institution should be a cultural centre to its community, where people may meet their friends in the context of scientific and beautiful objects and where amateur activities can be pursued under favourable conditions.

The report cites outstanding examples of what is urgently required, including the rebuilding of the damaged British Museum galleries, the raising of the purchase grant of the National, Tate and other art galleries, the provision of museums and art galleries in areas where the inhabitants have no ready access to such institutions, and the adequate financing of several now threatened with closure.

The survey naturally leads to recommendations, and emphasizes the need for the Government to realize that such a problem exists and that its very complexity demands a solution at the national, rather than the local, level. In order to achieve a flourishing and effective museums service it is recommended that a Royal Commission should be appointed at once and that some form of central advisory body should be established to integrate the work of the national and provincial museums. This could be done either by extending the powers and membership of the Standing Commission, or by the Ministry of Education, or by setting up an organization comparable to the University Grants Committee. Such a body should have at its disposal a block grant for distribution to individual museums, and in this connexion it is suggested that the grants should be made on the recommendation of regional museum bodies.

The memorandum issued over the signatures of Mr. Richard Carless and Miss Susan le Roux includes an appendix on the importance of the collections and work of the National Gallery, expressing the hope that it will be possible, as indeed it is eminently desirable, to secure the Hampton site for this great national institution.

The main theme of the recommendations of this important memorandum is in complete accord with that of other organizations vitally interested in the future of the museums and art galleries of Great Britain, and it is hoped that the Government will take heed of the unanimity of these representations.

---

* The Bow Group. Memorandum on the Museum and Art Gallery Service, with special reference to the National Gallery and the Hampton Site question. Pp. 14. (London: The Bow Group, 1958.) 1*s*.

INTELLECTUAL MYSTICISM

The Manifold and the One

By Agnes Arber. Pp. xiii+146. (London: John Murray (Publishers), Ltd., 1957.) 18*s*. net.

AGNES ARBER'S book is a study of the problem of the One and the Many from the standpoints of philosophy and of mysticism, and it is also a record of a personal quest continued over a long period. This personal note, though sternly restrained, gives an interest to her writing which carries the reader on through the somewhat compressed material which she has brought together from an amazing variety of sources. She makes no secret of her involvement in the problem. "I still remember vividly the glow of emotion aroused in me by the idea—which I discovered inside myself and treasured as my very own—that all such qualities as justice, love, and truth, are in reality *one*", she writes at the beginning of her book, and the "glow" appears again in her brief summing-up at the end.

Brushing aside as irrelevant the discussions of the Logical Positivists and the Semanticists, she considers the systems of metaphysicians from Anaxagoras onwards, in the conviction that most of them are based, consciously or unconsciously, on an intuition of the ultimate unity of the manifold or "the craving to see the universe *sub specie unitatis*". There is, in her view, a close affinity between the philosophical search for Reality and the mystic's search for union with the One. It is, of course, obvious that many systems end in a mystery which is not just a blank wall, but a Reality which is apprehended but not comprehended. In the survey of the mystics, which forms the most valuable contribution of her study and embraces both eastern and western examples, she gives the greatest weight to those that are least emotional and most intellectual. The essence of the mystical experience is "direct and unmediated contemplation characterized by a peculiarly intense awareness of a Whole as the Unity of all things".

It is difficult to convey in a review the quality of this book which, by reason of the rich material on which the writer works, calls for comment on almost every page. Probably only those who have themselves experienced the nostalgia for unity will be wholehearted students, but even those who are strangers to this 'intuition' can learn much from it about an important tendency in human thought and emotion through the ages. The Christian theologian will have his reservations and questions, particularly on the place of values in the Unity of the Manifold which, in the author's view, is the ultimate Reality. The distinctions of 'good' and 'evil', we are told, on this, the highest, plane vanish. The lines of Rumi—"The man of God is beyond fidelity and faith, To the man of God right and wrong are alike"—are quoted with approval. Why, one might ask, is the mystic way largely a way of 'purification', if, in the end, the One who is the end of that way is indifferent to all human values ? Perhaps we may see here why the Christian Church has been somewhat cautious about mysticism, and if this book has a defect, it is that it is too heavily weighted on the intellectual side. At any rate many, who have loved God and experienced union with Him, have loved Him because they believed Him to be the supreme Good and the enemy of evil. For such persons the beginning of their pilgrimage is to range themselves on His side. They have their right to be heard.

This is a valuable work and a learned one. It deserves to be read and pondered.

W. R. MATTHEWS

DUST, SMOKE AND MIST

Particulate Clouds

Dusts, Smokes and Mists—Their Physics and Physical Chemistry and Industrial and Environmental Aspects. By H. L. Green and W. R. Lane. (Spon's General and Industrial Chemistry Series.) Pp. xix+425+8 plates. (London : E. and F. N. Spon, Ltd., 1957.) 70*s.* net.

IMPLEMENTATION of the Clean Air Act requires control of the emission of dust and smoke from furnaces. This is partly achieved by the mode of operation of the process and partly by the collection of particulate material from the flue gases. The methods of collection that are available include gravitational settling, inertial separation, scrubbing, electrostatic precipitation, sonic and ultrasonic agglomeration. The variety of these methods illustrates the many mechanisms that operate in a particulate cloud. Physicists and chemists have contributed much to understanding of clouds during the past decade, following on the pioneer work of Gibbs, Patterson, Whytlaw-Gray, Drinker, Hatch and others. Notable contributions have been made by the Chemical Defence Experimental Establishment at Porton Down, and it is not unexpected to find that, in a book from this school, the authors have rightly attempted a unified treatment of the whole subject.

The task was by no means simple for, as the four pages of literature abbreviations show, relevant work has been published in a heterogeneous set of journals. Those venturing into this field of colloid science for the first time might well be glad of the further warning that the quality of the literature is uneven. The selected references given at the end of each chapter are, therefore, particularly valuable.

In the discussion of the physics and physical chemistry of clouds in the eight chapters of Part I, the essential instability of a cloud, owing to the mechanisms whereby the constituent particles can either grow or shrink, is clearly presented. Following chapters on the production of clouds and their physical characteristics, there is an interesting account of their optical properties. The basic electromagnetic theory has long been known, and, now that the necessary computations have been carried out, experimental data can be interpreted adequately. There follows a long account of coagulation, one of the most important properties of a cloud ; this chapter is fundamental to a proper understanding. The next two chapters on deposition and filtration and on sampling and estimation give descriptions of the many ingenious devices that have been developed, dependent on such varied mechanisms as impaction on an obstacle in a flowing stream, thermal and electrostatic precipitation. Lastly, there is an up-to-date discussion of diffusion in the atmosphere.

Industrial and environmental aspects are covered in Part II. Following a brief chapter on collection, accounts are given of health hazards, atmospheric pollution, aerosols in Nature and, lastly, some uses of particulate clouds. These titles indicate the range of phenomena in which clouds have importance, and the treatment illustrates the authors' thesis that many different types of cloud have essentially the same properties. Thus, the theory of impaction of particles on obstacles is applied in the icing of aircraft, the filtration of dusts and smokes, the capture of windborne pollen, the growth of raindrops and the application of insecticidal aerosols.

These examples serve as an illustration of the value of classical scientific studies at the present time, not only to elucidate natural phenomena but also to improve the operation of industrial equipment. Newer as well as the older technologies have need of the knowledge of clouds gained in the past thirty years. Scientists and technologists will find in this timely book a worthy introduction.

The book is well printed and is substantial enough to warrant its price.

R. L. BROWN

PRODUCTIVITY AND SOCIAL ORGANIZATION

Productivity and Social Organization

The Ahmedabad Experiment—Technical Innovation, Work Organization and Management. By A. K. Rice. Pp. xiii+298. (London : Tavistock Publications, Ltd., 1958.) 35*s.* net.

IMPROVED technology has greatly contributed to the rising level of industrial productivity. But there is a danger in some situations that technological change may neglect the social and psychological needs of the human operator and so reduce substantially the potential rise in output per man-hour. There are a number of studies of the human implications of technological change. But only recently has a method of analysis been evolved which treats a production system as an organic whole, and enables the social dimension to be designed to meet both human and technological requirements in a systematic manner. This method of analysis has arisen from the concept of a 'socio-technical' system introduced by E. L. Trist and his colleagues, of whom Mr. Rice is one, at the Tavistock Institute of Human Relations. The concept of a socio-technical system, together with the developing theory of social structure and the work of W. R. Bion on the conscious and unconscious behaviour of small groups, lays much of the conceptual foundation for the experiments carried out by Mr. Rice in the operational setting of a large Indian textile firm and described in this book.

Mr. Rice worked as a management consultant, and his primary professional responsibility was toward his client. The fact that his client's share prices doubled in value after his three-year period of work at a time when other textile firms were failing suggests that Mr. Rice's contribution in this role was by no means ineffective. But he also worked in an operational research role. Here he used as his quantitative data the commercial and technical facts of the firm, and as his qualitative data the feelings of people. His findings are logically presented and he offers some challenging hypotheses concerning both technological change and the theory of organization.

Mr. Rice's first task was to examine the working of the automatic loom sheds, where despite the introduction of Western technology, productivity and quality were low. An analysis of the socio-technical system showed that "because the workers formed only an aggregate and not a working group, and because the jobs were broken down into component operations" stable relationships were impossible. Nobody experienced either as an individual or in a group the satisfactions deriving from the "completion of a whole task". The production system was therefore re-organized to provide adequate satisfactions in the social dimension. This was followed by a similar reorganization of the non-automatic loom sheds. Despite many difficulties, some of them peculiar to the Indian scene, productivity and quality rose to the levels required by management, in both sheds.

Mr. Rice's third major task was to examine the management organization of the firm. His theory of the differentiation of organization structure into managing and operating systems represents a radical departure from the outworn 'machine' theory of organization and provides an organic model for the study of organizations. Using this model, which is derived from von Bertalanffy's theory of open systems, it is possible for the first time to determine by means of operational criteria where and at what level management functions such as control and services should be placed in an organization. As Mr. Rice remarks, "difficulties between managers are frequently caused by confusion between control functions and operations", and one can only guess at the loss of both productivity and human satisfaction in almost every firm for this reason alone. This new thinking deserves most serious consideration, and I believe it will prove to be a major contribution to the theory of social organization. If there is any criticism to be made, it is that more detail would have been welcomed on the organizational changes and the difficulties which were incurred in making them. No doubt we shall have to wait for this until another occasion. The fact that these remarkable experiments took place in an Eastern culture demonstrates not the limitations but the wide applicability of this integrated approach to a central problem of our time. This is an important book not only for social scientists but for all who are concerned with the tasks of administration in any field.

S. DAVID M. KING

JOLLY GOOD COMPANY

Earth's Company

By Leslie Reid. Pp. xi+221+12 plates. (London: John Murray (Publishers), Ltd., 1958.) 25*s*. net.

WITHIN the last decade a spate of books describing various aspects of biology has been published with the avowed aim of interesting the intelligent layman and setting before him different facets of the great natural panorama. Some of these books, notably in the New Naturalist series, have been very successful, combining interest, accuracy, and a dispassionate approach to scientific problems which are wholly admirable. "Earth's Company" makes an attempt to follow this pattern, but goes off on a rather different tack.

Leslie Reid has put three component parts into his book. It is on the surface a description of many aspects of, mainly animal, ecology such as coloration, prey–predator relationships, parasitism, movement of individuals and societies, courtship, etc., and an attempt is made to show that "each single phenomenon of nature has no meaning, no existence, except by virtue of its relationship with all the other phenomena" (p. 208). The ecological accounts are interesting, but on the whole elementary and rather sketchy. In fact in many places the author apologizes for the summary nature of his treatment; for example, work on behaviour in mammals is discussed in a very vague paragraph of ten lines.

However, if one assumes, as one must, that this book is intended for a lay audience, then these weaknesses may be excused. There are, however, a number of inaccuracies; for example, on p. 34 it is stated that "the dominant plants . . . are always the most numerous" and that "natural mutations are extremely rare" (p. 124). These statements depend on the definition of the dominant plant, for if an oak tree is the dominant in an oak wood then there are certainly many more herbaceous plants than there are oaks, and mutations are only rare if one is thinking in terms of one particular mutation at a certain locus in one individual, but in large populations with many loci each capable of more than one mutation then the problem of rarity is not so insuperable.

At a slightly sub-surface level, the author is directing attention to the beauty and intricacy of many natural processes. It is this aspect of the book which is most satisfactory, and it leaves the reader with a sense of marvel and maybe even of awe. The examples are chosen to fulfil this special purpose and they do so very well. His statement, however, that to scientists "the æsthetic appeal of their subject seems to be one that many of them feel ashamed of" is, I feel, unjust and very often untrue, for most scientists are conscious of the beauty that can and does lie in their material, in their apparatus, and in their experimental and mathematical proofs.

The third component of this book follows naturally from what I have called the sub-surface level, for he states that since the world of Nature is strange, beautiful, intricate, yet finely adjusted to operate as a unit, then there is "in it striking evidence of some directing intelligence" (p. 143). From this philosophic standpoint much of the material comes to be presented in a very teleological manner; for example, "marine animals . . . will avoid water that is fresh, because if they fail to do so they will perish" (p. 45). Such an attitude despises "the laws (if they can be called laws) of chance" (p. 124), and in consequence minimizes the achievements of modern genetics and replaces these by a mystic power. Thus evolution becomes a process in which "it is as though (and why not ?) the change had been foreseen and allowed for in the course of the animal's evolution" (p. 140).

This is not a bad book. It is well written and illustrated, full of interesting examples and personal anecdotes, but the theme is too grand for 221 pages and its insistence on direction by a "guiding intelligence" may ring very strangely in the ears of those of its readers with a biological training.

Alan R. Gemmell

TREES AND SHRUBS

The Book of Flowering Trees and Shrubs

By Stanley B. Whitehead. Pp. 244+63 plates in colour. (London and New York: Frederick Warne and Co., Ltd., 1956.) 15*s*. net.

THIS pocket-size book is a companion volume to "The Book of Garden Plants" by G. A. R. Phillips, and is illustrated by the same artist, Miss Joan Lupton. It deals with shrubs, small trees and climbers, and by far the greater part of the text, 178 out of a total of 244 pages, is devoted to brief descriptions of 230 genera (not 240 as stated in the preface). Seven genera are divided into two or more parts, and each part is dealt with as though it was a genus, so that altogether there are 248 accounts of genera and subdivisions of genera, each with notes on the species or a selection of the species. The genera are arranged alphabetically, and each genus or subdivision is illustrated by a small coloured figure of one of its species. These figures, set four on a page, are sufficient to give the reader some idea of the sort of plant described, but they suffer the usual defect of their kind, namely, the almost complete failure to render the green of the leaves even approximately the right colour. The information given in the text is reasonably accurate, and the book may justly be regarded as "a simple and non-technical guide" to the choice, identification and qualities of flowering shrubs and small trees for the modern garden—which is what it is intended to be. As such, it should prove very useful. It must be pointed out, however, that many of the genera included are hardy only in the mildest parts of the British Isles.

In addition to the descriptive matter, there are chapters on shrubs in the modern garden, soils and situations, planting and propagating, and care of trees and shrubs. Short lists of species suitable for different soils and various situations are given, there are an illustrated glossary and, finally, an index. A reference to the method of propagation is given for each genus, and there are ten pages of details about the various methods; these details scarcely seem necessary in a book of this kind.

There are occasional examples of slipshod writing like "The genus is one of three species . . .", and the author has an irritating habit of using the word 'group' instead of 'genus'. The word 'trees' in the account of *Nuttallia* was no doubt a slip of the pen, and the same may account for the home of *Acer griseum* being given as Cochin China instead of Central China. *Stranvaesia davidiana* is a native of China, not of the Himalayas. *Rhododendron griersonianum*, shown on Plate 50 as an example of a hybrid rhododendron, is a good species, while *R. bullatum*, shown as a deciduous species, is an evergreen. One understands, and sympathizes about, the unfortunate oversight which led to the printing on p. 191 of "dry, splitting-capsule seed-vessel"—it happens to us all—but I have quite failed to elucidate "*M[alus] trilobata*, Syria, becomes a fine accent with columnar growth to thirty feet, . . .". Incidentally, this species is recorded from Palestine and the Balkan Peninsula in addition to Syria.

J. Robert Sealy

DYNAMIC BIOCHEMISTRY

Dynamic Aspects of Biochemistry

By Prof. Ernest Baldwin. Third edition. Pp. xx+526. (Cambridge: At the University Press, 1957.) 37*s*. 6*d*. net.

THIS has become a classic among biochemistry books. Prof. Baldwin received an international prize for writing it, and it has been translated into half a dozen languages including Russian and Japanese. It has long been a best-seller, valued alike by students and their teachers. It was natural, therefore, to feel anxiety on opening this new edition, lest the book might have lost its familiar and unique character. The first glance was reassuring. The author's well-known whirligig arrows, indicating coupled reactions, still cover the pages; one still learns that spiders excrete guanine; the sequence figs, fire-flies and fishes is still found in the new, shortened index. Having said this, the reviewer has to admit to a feeling of disappointment that some of the most outstanding advances of the past five years have not found their way into this new edition. Among these, the researches of Sanger on insulin and of du Vigneaud on the posterior pituitary hormones at once come to mind. Perhaps the author thought of these as structural rather than dynamic aspects, but he must have found it hard to exclude them. Again, some discussion of the biosynthesis of sterols and porphyrins and a more up-to-date account of the thyroid hormones would have been welcome.

The difficulty, of course, is to suggest what could have been left out to make room for new material, and opinions will, no doubt, differ on this. The book does not claim to be a complete text-book of biochemistry. Indeed, one of its great merits is that it is selective, and students will be thankful that its size (and its price) have not been much increased. There are, though, some sections, carried over from the original edition, which might perhaps have made way for more live topics. For example, less space might have been given to the descriptions and structures of some of the more uncommon nitrogenous bases. The obscure artefact creatone occupies half a page, though noradrenaline and 5-hydroxytryptamine are, apparently, not mentioned anywhere. The main consideration, though, is that Prof. Baldwin has chosen to write on selected topics which interested him, and has done it supremely well, in language which is simple, forthright and vivid.

It would be wrong to give the impression that this edition does not contain any new material. To mention examples, there is a new chapter on the photosynthesis of carbohydrates in green plants, the chapters on the metabolism of carbohydrates and of fats have been substantially revised, the sections on purine synthesis, on oxidation systems and on subcellular fractions have been enlarged, and many small revisions have been made throughout the book. A good many misprints have been allowed to slip through, more than would have been expected in a book of this importance.

Biochemists will be grateful to Prof. Baldwin for rejuvenating his famous book and will wish it many further years of vitality. Of course it still carries its original dedication "To Hoppy". Gowland Hopkins's teaching and outlook still permeate it: there could be no higher recommendation. D. C. HARRISON

ALL ABOUT RHEOLOGY

Rheology

Theory and Applications, Vol. 2. Edited by Frederick R. Eirich. Pp. xiii+591. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 18 dollars.

IN his preface, the Editor discusses three criticisms from reviews of the first volume: "overlap or repetitions, unequal approach or even conflicting views, and non-uniformity of nomenclature" (see *Nature*, 179, 1207; 1957). If one is prepared to accept his views on these three points, there is indeed little to criticize in the second volume. Like the first, it contains a series of admirable essays on subjects of current rheological interest, by authoritative writers.

But I cannot altogether accept the Editor's dismissal of these earlier criticisms. While some overlapping is inevitable and even desirable, the size and the price of the book might have been reduced with some advantage by excluding material readily available elsewhere. One can scarcely suppose that this three-volume work, important as it is, will serve as the only source of information for any rheologist who is sufficiently advanced in his subject to follow its treatments. The most striking example is an otherwise excellent chapter on fibres by R. Meredith. This author edited and largely wrote a whole book[1] on this subject only two years ago. There would seem to be little advantage in including a fifty-page summary of this in the present work.

On the question of symbols, one appreciates the Editor's difficulties with the more specialized properties and concepts; but at least most English-speaking rheologists are already in fairly general agreement on the symbols which are most widely used. It is welcome news that "it is hoped that, by the time the third volume is ready to go to press, efforts to unify nomenclature may have reached a point where they can be applied to this book".

The subject-matter of the book divides itself naturally into three parts. The first seven chapters deal with mainly theoretical aspects of the rheology of high-polymers, Chapters 8–10 are concerned with gelatin, asphalts and geo-rheology, and the last three chapters describe experimental techniques. The middle section, especially the chapters on gelatin by A. G. Ward and P. R. Saunders and that on geological problems by B. Gutenberg, are particularly valuable, since the contents are not readily available elsewhere. The practical rheologist, for whom the earlier chapters are directly applicable to his everyday work, will get relaxation and intellectual pleasure from reading this most lucid account of how elastic moduli, viscosities and relaxation times are computed for the great masses of material which stretch for many miles beneath our feet.

Chapters 11 and 12, especially the latter, contain little that is not already on the shelves of most readers, but Chapter 13, on goniometric methods, by A. Jobling and J. E. Roberts, will suggest new and exciting possibilities to many practical rheologists.

This book, like its predecessor, is beautifully produced and printed; and Volume 2 is singularly free from misprints, though the printers still seem to have trouble (p. 207) with the spelling of "Treloar".

Such stringent criticism of a book is justified only if it is felt that the work is one of outstanding importance and of exceptional merit. In the present case there can be no doubts on this score.

G. W. SCOTT BLAIR

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[1] Meredith, R., "Mechanical Properties of Textile Fibres" (North Holland Pub. Co., 1956).

WEIGHT REDUCTION IN THE HUMAN SUBJECT

This Slimming Business

By Prof. John Yudkin. Pp. 191. (London: MacGibbon and Kee, Ltd., 1958.) 15*s*. net.

THE medical advances, permitting more people of the Western World to reach old age, and the changed dietary habits of modern civilization associated with declining physical activity have focused attention on the need for weight control. Most accounts of this subject are either long scientific tomes on nutrition or uninformed accounts in the fashion or advertisement columns of newspapers and periodicals. This book claims to explain in non-technical language why some people are overweight and what they can and ought to do about it. It seems to be written mainly for women, but the information it presents could take an important place in the serious literature of the subject. It is, however, written in a chatty style more suited to the spoken than the written word and is likely to be appreciated more by those who would prefer to read a short newspaper article than the whole of this book.

The first seventy pages are concerned mainly with some general conceptions and misconceptions of obesity. An attempt to explain to the layman the significance of biological variation in relation to normal body-weight, although comprehensible to the scientific reader, seems to have been less successful with an overweight professional journalist of a national newspaper (*Daily Mail*, May 5, 1958).

There follows a brief but excellent account of nutrition that should enable the non-scientific reader to appreciate the reasons for the condemnation of much of the published nonsense on dieting. Pages 106–114 are not particularly illuminating—and with advantage could have been replaced by more compact pictorial diagrams.

The author then presents his case for controlling weight by reducing carbohydrate rather than fat calories. One cannot accept his implied argument that modern man is healthier on the carnivorous diet than his primitive forbears, but the general idea is sound that the fundamental fault of the present-day diets is that increasing wealth permits increasing dietary protein and fat without corresponding decrease in the intake of foodstuffs such as cakes, ice cream, biscuits and sweets. There is no doubt that many people can lose excess weight with a diet low in carbohydrate but unrestricted in protein and fat. The case for not restricting protein is unanswerable; that for allowing unrestricted fat is on less certain ground. According to Prof. Yudkin, restriction of carbohydrate will usually be associated with relatively little, if any, increase in fat, but many people will take extra cream with their fruit and butter with their peas and beans. He wisely avoids discussing the possible effects of dairy fats and unsaturated vegetable fats in increasing or decreasing, respectively, the incidence of coronary disease.

In presenting his slimming regime, the author has taken a leaf from the notebook of the diabetic. Lawrence's line-ration scheme enabled the great majority of diabetics of widely differing mental acumen to control carbohydrate intake while retaining freedom of selection of foodstuffs. Lawrence's unit was the black portion corresponding to 10 gm. carbohydrate, and all the intakes of diet were tabulated according to the number of such portions they contained; Yudkin has selected 5 gm. carbohydrate as his unit, wisely since he hopes to restrict his slimming subject to 4 or less of such units, whereas diabetic patients require much more. This scheme provides an acceptable method of caloric reduction deserving wide use.

One can quarrel with little of the scientific content of this book, although the physiological reality of the 'appestat' is open to some doubt. Many authorities believe that water retention may play an even more important part than the author suggests in delaying weight reduction in subjects on diets of undoubted efficacy. CHARLES H. GRAY

DYNAMICS OF FISH POPULATIONS

On the Dynamics of Exploited Fish Populations

By R. J. H. Beverton and S. J. Holt. (Ministry of Agriculture, Fisheries and Food—Fishery Investigations, Series 2, Vol. 19.) Pp. 533. (London: H.M. Stationery Office, 1957.) 126*s.* net.

THE cover jacket of this important work states that, "Many of Beverton and Holt's methods will be applicable to other living populations—animals or plants—and their theoretical framework should form part of the syllabus of teaching in agriculture, in ecology, in geography, in sociology, and in nature preservation". This is a wide claim but true enough in so far as the application of mathematics to the study of fish is ahead of its application to populations of land organisms. The book is in four parts, of which the first two are primarily theoretical representations of the four primary factors, recruitment, natural mortality, fishing mortality and growth. The application of the theoretical methods is developed in Part 3, concerned with the estimation of parameters, and in Part 4 where population models containing these parameters are used to investigate the reactions of fish populations to exploitation. The argument is here primarily concerned with North Sea plaice and haddock, but examples are taken from other fish, including perch in confined lakes, which offer particular opportunities for getting to grips with population problems.

Some readers, more interested in the practical applications than the theoretical analyses, will doubtless turn straight to Part 4, but this would do the book less than justice, because it is mainly in the mathematical treatment of the subject that new ground is broken. But, while the authors are to be admired for their enterprise after seven years of effort in compiling a work of such magnitude, bringing into prominence the role of mathematical models in ecological theory and application, their methods are not beyond criticism. The work would, indeed, have benefited by a closer revision, for some of the lucidity is lost at critical points. In the treatment of random migration, for example, the authors get into rather deep water because they do not distinguish clearly between the case where displacements (d) are constant in magnitude and that where the displacements are variable. In this way they confuse the mean value of d^2 with the square of the mean value of d, whereas in the analogy they draw with the kinetic theory, the former is twice the latter.

Proofs of essential theorems are usually given fully, but some readers may be discouraged by arrays of impressive symbols, contortions and rearrangements, where simple and lucid arguments are available. For example, pages 37 and 38 are devoted to demonstrating in a particular case that the total annual yield from a steady-state population is the same as the yield from a single recruitment class followed through its life, an obvious and general result which can be rigorously proved in a few lines without mathematics. Again, the theorem on pages 39–40 is a rather unnecessary exercise in elementary summation and integration, for it follows immediately from the more easily demonstrated theorem that an exponentially declining population grouped into year classes is geometric. There are several instances where the formulation of the problems could have been more fully stated with the exact conditions, and with their formal enunciation more prominently displayed and numbered. Some ambiguity might thereby have been avoided.

There is a useful and extensive bibliography which, however, appears somewhat deficient on certain central themes. No mention is made in the text of the classical work of Lotka on stable age-structures, and the growth equations discussed at length are attributed to Bertalanffy (1934) instead of Pütter (1920). A few references could well have been omitted, for example that to Pétart (1938), because the serious reader unacquainted with higher mathematics might misunderstand its humour.

These criticisms, however, do not detract materially from the high value of this book as a major contribution to fishery science and a source of reference and interest to workers in mathematical biology. He who thinks in terms of living organisms rather than of symbols will inevitably take some buffeting, but it is pleasing to find support given to "the tradition dating from T. H. Huxley's time, and reaffirmed by Graham, that the best management of fishing is to leave it alone until events show that intervention is necessary". There is a useful index.

E. B. WORTHINGTON
J. G. SKELLAM

NEW ACADEMIC PRESS BOOKS

Electronic Digital Computers

THEIR USE IN SCIENCE AND ENGINEERING

By F. L. ALT, *National Bureau of Standards, Washington, D.C.*

September 1958, 336 pp., illus., 80s.

THIS BOOK GIVES a complete and up-to-date survey of the techniques available for using electronic computers. It describes machines from a functional standpoint, concentrating upon aspects of interest to the potential user, and discusses all phases of problem formulation and analysis, programming, coding, and machine operation.

One of the unique features of the book is the balanced presentation of information about the capability and utility of various types of machines which should enable the scientist, engineer or other user to judge the suitability of a given machine for his particular problem.

Electronics of Microwave Tubes

By W. J. KLEEN, *Siemens & Halske Aktiengesellschaft, and Technische Hochschule, Munich, Germany*

Translated from the German by P. A. LINDSAY, A. REDDISH, and C. R. RUSSELL *The General Electric Company, Ltd., Wembley, England*

September 1958, 349 pp., illus., 72s.

THIS BOOK PROVIDES a unified treatment of the microwave tubes currently in use. A presentation of the fundamental processes involved is followed by a clear discussion of tube applications, noise, and the most important structural components—resonators, delay lines, and electron guns. The author explains, both qualitatively and quantitatively, the effects governing the operation of those microwave tubes now used in telecommunications.

A NEW SERIAL PUBLICATION

Modern Materials

ADVANCES IN DEVELOPMENT AND APPLICATIONS

Edited by HENRY H. HAUSNER, *Consulting Engineer, and Adjunct Professor, Polytechnic Institute of Brooklyn*

VOLUME 1

October 1958, 402 pp., illus., 89s. 6d.

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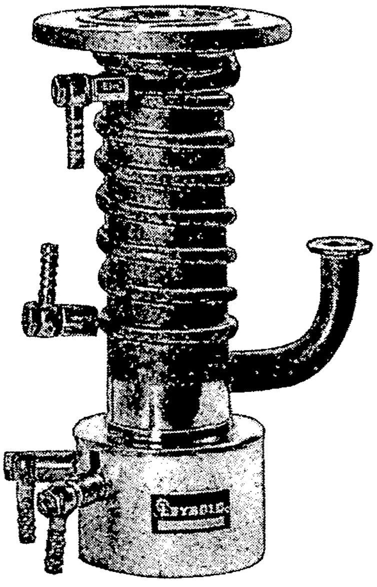

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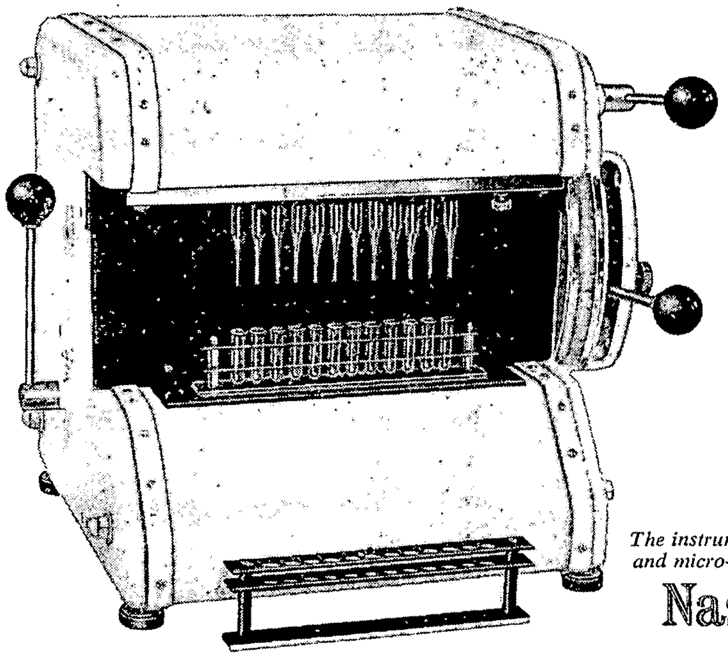

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BIOCHEMISTRY OF CELLULOSE AND RELATED POLYSACCHARIDES*

By Dr. B. A. STONE
Biochemistry Department, University College, London

THE naturally occurring β-glucans (polymers of β-D-glucopyranose) which are listed in Table 1 form a series of structurally related polysaccharides. Many of these glucans, for example cellulose, callose and yeast glucan, are constituents of cell walls; while others, such as the *Pneumococcus* type III and *Rhizobium* polysaccharides, occur as capsules associated with cell walls. A number of them are intracellular, for example laminarin and lichenin, and may be regarded as reserve polysaccharides, while others are extracellular and of unknown significance (the β-glucans of bacteria and fungi).

Cellulose is the most abundant β-glucan; its structure and organization in the cell walls of higher plants have recently been reviewed[1]. The β-1 : 3 glucans are less well known, although as early as 1890 Mangin[2] reported the occurrence of an insoluble polysaccharide in the sieve plates of the phloem and in pollen tubes and pollen grains. The polysaccharide, which he named callose, he distinguished from cellulose by its insolubility in cuprammonium and by differential staining reactions. Callose replaced cellulose, or occurred with it, in the mycelium and fruiting bodies of many families of fungi, yeasts, lichens and some algæ. These observations have not been confirmed in any detail, but three β-1 : 3 glucans, callose, pachyman, and yeast glucan have similar properties to Mangin's callose and are found in similar situations.

Table 1. Basic Structures and Distribution of β-Glucans

	Ref.	Main linkages	Other linkages	Other monomer units	Distribution
Cellulose		1–4	—	—	Cell walls throughout plant kingdom Test of Tunicates, mammalian tissues ?
Pachyman	*a*	1–3	—	—	*Poria cocus* sclerotia
Yeast glucan	*b*	1–3	1–2	—	Cell walls of some yeasts, for example *S. cereviseae*
Callose	*c*	1–3	—	Uronic acid (2 per cent)	Sieve tubes in phloem of grape vine
Laminarin	*d*	1–3	1–6	Mannitol (2–3 per cent)	Fronds of some Phaeophyceae
Lichenan	*e*, *f*	1–3 (30 per cent) 1–4 (70 per cent)	—	—	Fronds of some lichens, notably *Cetraria icelandica*
Oat glucan	*g*	1–3 (30 per cent) 1–4 (70 per cent)	—	—	Oat grain
Barley glucan	*h*	1–3 (50 per cent) 1–4 (50 per cent)	—	—	Barley grain
Pneumococcus type III polysaccharide	*j*	1–3 (50 per cent) 1–4 (50 per cent)	—	Glucuronic acid (50 per cent)	*Diplococcus pneumoniae* type III capsule
Rhizobium polysaccharide	*k*	1–4	1–6	Glucuronic acid	*Rhizobium radicicola* capsule
Pustulan	*l*	1–6	—	—	Fronds of the lichen *Umbilicaria pustulata*
Luteic acid	*m*	1–6	1–3, 1–4	Esterified malonic acid	Culture media *Penicillium luteum*
Crown gall polysaccharide	*n*	1–2	?	—	Culture media *Phytomonas tumefaciens*

(*a*) Warsi, S. A., and Whelan, W. J., *Chem. and Indust*, 1573 (1957); (*b*) Bell, D. J., and Northcote, D. H., *J. Chem. Soc.*, 1944 (1950); (*c*) Aspinall, G. O., and Kessler, G., *Chem. and Indust.*, 1296 (1957); (*d*) Peat, S., Whelan, W. J., and Lawley, H. G., *J. Chem. Soc.*, 724, 729 (1957); (*e*) Chanda, N. B., Hirst, E. L., and Manners, D. J., *J. Chem. Soc.*, 1951 (1957); (*f*) Peat, S., Whelan, W. J., and Roberts, J. G., *J. Chem. Soc.*, 3916 (1958); (*g*) Acker, L., Diemar, W., and Samhammer, E., *Z. LebensmittUntersuch.*, **102**, 225 (1955); (*h*) Aspinall, G. O., and Telfer, R. G. J., *J. Chem. Soc.*, 3519 (1954); (*j*) Reeves, R. E., and Goebel, W. F., *J. Biol. Chem.*, **139**, 511 (1941); (*k*) Schlüchterer, E., and Stacey, M., *J. Chem. Soc.*, 776 (1945); (*l*) Lindberg, B., and McPherson, J., *Acta Chem. Scand.*, **8**, 985 (1954); (*m*) Lloyd, P. F., Pon, G., and Stacey, M.. *Chem. and Indust.*, 172 (1956); (*n*) Putnam, E. W., Potter, A. L., Hodgson, R., and Hassid, W. Z., *J. Amer. Chem. Soc.*, **72**, 5024 (1950).

Several β-glucans with both 1 : 4 and 1 : 3 linkages are found naturally; those which occur in cereal grains are important in the germination process[3]. Thus oat glucan is located on the surface of the kernel, and during germination, it has been suggested, it is dissolved away by β-glucanases allowing access into the endosperm of enzymes concerned with the mobilization of starch[4].

Biosynthesis

Our knowledge of the biosynthesis of β-glucans has, until recently, been limited, and most of our information relates to cellulose synthesis. Analytical studies of the changes in carbohydrates in the developing cotton plant[5] and of the pathways of carbohydrate metabolism in *Acetobacter xylinum*[6] have led to the suggestion that hexose phosphate is involved in cellulose synthesis. In neither system was cellobiose utilized; thus, although transglucosylations involving the formation of oligosaccharides from cellobiose have been reported, they do not appear to be concerned in cellulose synthesis[7]. Experiments involving the incorporation of labelled carbon, administered as monosaccharides, into the cellulose of *Acetobacter* spp.[8] and of cotton[9] and wheat plants[10] have shown that the C-1 of glucose-1-^{14}C is usually retained to the extent of 60–80 per cent in its original position, although the conditions of the experiment and the physiological status of the plants greatly influence the amount of retention. These results suggest that, although some glucose can be polymerized directly into the cellulose molecule, a proportion of the monomer units of the cellulose arise by resynthesis of fragmented glucose molecules. Similar experiments have been extended to the xylan of the wheat plant by Altermatt and Neish[10]. The results suggest that the xylose units arise by the oxidation of the hexose at C-6, followed by decarboxylation.

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* Based on two lectures delivered at University College, London, on May 5 and 12.

In cell-free systems from *A. xylinum*, prepared by Mickle disintegration[11] or glass-grinding of freeze-dried cells[12], cellulose synthesis can occur when glucose and adenosine triphosphate are added. Greathouse[12] showed that 96·7 per cent of the label was retained in the C-1 of the glucose units when glucose-1-^{14}C was used as substrate.

Uridine diphosphate-glucuronic acid and uridine diphosphate-glucose have been established as glycosyl donors in the formation of glucuronides[13] and disaccharide phosphates[14] respectively. Altermatt and Neish[10] have suggested a scheme for the synthesis of plant polysaccharides in which these types of compounds are envisaged as donors, or close precursors of donors, of the polymerized units. Their ideas are supported by the isolation, from mung bean seedlings, of a number of nucleotide glycosyl compounds and of enzyme systems involved in their formation and interconversion[15]. They are further supported by a report[16] of the synthesis of cellulose by cell-free preparations of *A. xylinum* from the labelled glucose of uridine diphosphate-glucose. Uridine nucleotide glycosyl compounds have also been implicated in the synthesis of chitin, hyaluronic acid and glycogen[17], on the basis solely of experimental evidence of the incorporation into the polysaccharide of labelled monomer supplied as the nucleotide glycosyl compound. Whether the monosaccharide of the nucleotide sugar derivative is transferred directly by a single enzymic step or whether indirectly by several steps is unknown. Until the synthesizing systems have been further examined and purified the exact role of the nucleotide derivatives will remain uncertain.

Among the β-glucans there exist representatives of many of the types of structures encountered among the polysaccharides, including unbranched chains, involving the same positional linkage type between each unit as in cellulose or two different linkage types as in lichenan, and branched chains. Among related polymers are structural types in which different monomer units are joined by linkages of the same positional but different configurational types, for example the pneumococcal type VIII capsular polysaccharide which has the repeating unit[18]:

$$\text{-}\beta\text{-}\mathrm{D}\text{-}\mathrm{G}p\mathrm{A}\text{-}(1 \rightarrow 4)\text{-}\beta\text{-}\mathrm{D}\text{-}\mathrm{G}p\text{-}(1 \rightarrow 4)\text{-}\alpha\text{-}\mathrm{D}\text{-}\mathrm{G}p\text{-}(1 \rightarrow 4)\text{-}\alpha\text{-}\mathrm{D}\text{-}\mathrm{Gal}p\text{-}(1 \rightarrow 4)\text{-}$$

(where G*p*A = glucopyranuronic acid; G*p* = glucopyranose; Gal*p* = galactopyranose), and a further type, often found among the xylans, has short side chains of xylose or other sugars attached to the main β-xylose chain.

This wide range of structural types makes any generalized statement about the mechanism of synthesis difficult, but clearly two systems would be required, the first concerned with the provision of building units of the right configuration and state of activation, which could be utilized by the second or polymerizing system and built into the characteristic structure of the polymer. We know that both these systems are under genetic control[19], and although there is some information concerning the provision of donor molecules the polymerization system for β-glucans is not understood at all. Two possibilities exist for this system. First the synthesis may be directly under enzymic control as it is, for example, in the synthesis of glycogen. However, for the synthesis of polysaccharides having different linkage types and perhaps different monomer units, the number of enzymes required would be large, their specificities restricted and often novel in character in order to direct the synthesis in a reproducible manner. The second possibility, that the synthesis is under the control of a template, has been put forward, and is considered in detail by Wilkinson in his recent review on bacterial polysaccharides[19].

It is possible to envisage the synthesis of certain polysaccharides, for example lichenan, pneumococcal type III and VIII polysaccharides (Table 1), as a polymerization of a preformed repeating unit by transglycosylation from a suitable donor. Here the sequence of units in the repeating block and their mode of linkage would be controlled either by a number of specific enzymes or by a template mechanism. Some support for this type of process is provided by the evidence, summarized by Park[20], that the nucleotide sugar amino-acid compounds, which he isolated from cultures of penicillin-inhibited *Staphylococcus aureus*, are involved in the synthesis of the bacterial cell wall.

Several of the β-glucans, including bacterial cellulose, occur extracellularly. The problem of their synthesis and appearance outside the cell is analogous to that posed by the occurrence of other high molecular weight compounds in the medium surrounding cells, for example exo-enzymes, hormones and antibodies. This problem is related in a direct way to the mechanism of the synthesis. For certain types of polysaccharides such as dextrans and levans, the synthesis can occur in the extracellular medium if suitable donor molecules are provided. For extracellular protein and probably for many polysaccharides the building units are only found intracellularly together with the system which controls the specific arrangement of the units in the polymer. This raises the problem of the selective release from the cell of the macromolecule. In the case of the bacterial cell wall complex and the capsular and extracellular polysaccharides it is possible to envisage an enzymically controlled synthesis at the cell surface (plasma membrane) or the formation there of activated units which can be polymerized extracellularly by extracellular enzymes. The problem is well illustrated by the synthesis of bacterial cellulose, where electron microscope studies indicate that the cellulose microfibrils are formed in the medium remote from the cells[21]. If this is correct then the immediate donor of the polymerized units may be found in the medium together with the transferring enzyme. Although uridine diphosphate-glucose is implicated in cellulose synthesis[16] it is unlikely to be an extracellular donor since the nucleotide portion would be lost to the cell. Some intermediate reactions appear likely. A speculative scheme based on an analogy with the formation of lactose, trehalose and sucrose phosphates[13] from uridine diphosphate-glucose and glucose-1-phosphate,-6-phosphate, and fructose-6- or 1-phosphate might involve the formation of cellobiose phosphate as an intermediate, perhaps at the plasma membrane surface. Transfer of cellobiose from its phosphate to suitable acceptors (primers) would result in the formation of cellulose molecules.

Cellobiose has something to recommend it here since it is the true repeating unit of cellulose. The isolation of an oligosaccharide phosphate and cellodextrins from the medium of actively synthesizing *A. aceti-genum* cultures is consistent with this scheme[22].

Depolymerization

The enzymic depolymerization of cellulose and other β-glucans has not been investigated at the biochemical level with the same intensity as has starch degradation. For cellulose the heterogeneous nature of the reaction system and the complexities raised by the supramolecular structure of the substrate have been the chief check to progress.

The facility with which bacteria and fungi attack cellulose contrasts with the slow and incomplete attack by cell-free enzyme preparations on organized celluloses. The difference has been argued as being due to the loss of labile enzymes in preparation[23], although the characteristic localization of the attack by bacteria and fungi suggests that the enzyme concentration at the site of dissolution, the localization of the cellulase at the cell surface in bacteria[23], and removal of reaction products might also be important factors in explaining the difference.

The effect of the supramolecular structure of the substrate on the action of cellulases has been thoroughly investigated[24], and it is clear that the attack is initially limited to the regions of low lateral association of the cellulose molecules and that any treatment of the cellulose which will increase the proportion of the less ordered regions will increase the extent of hydrolysis. Frequently the attack on the molecular chains has been shown to be by a random mechanism[25], and although there are reports that endwise attack on the chains can occur the evidence is indirect[3, 26].

Whitaker[27] has shown that a fractionated and apparently unienzymatic cellulase preparation from the mould *Myrothecium verrucaria* can hydrolyse cellulose-type molecules with lengths corresponding to a degree of polymerization of 3 and upwards. Thus a single enzyme may be responsible for an almost complete depolymerization, although the results of analysis of crude cellulase preparations from *M. verrucaria* and other fungi by a variety of fractionation procedures suggests that they are complex systems with several active components[28]. Unfortunately the components have not been obtained in a state which would allow differences in their chemistry and specificity to be clearly demonstrated.

Many cellulase preparations also contain a cellobiase and it was early suggested that cellulose hydrolysis might be a two-step process :

$$\text{cellulose} \xrightarrow{\text{cellulase}} \text{cellobiose} \xrightarrow{\text{cellobiase}} \text{glucose}$$

In some cases cellobiase activity is not limited to the disaccharide as is shown by the properties of the two fractions obtained by alumina chromatography of *Aspergillus oryzae* preparations[29]. One was termed an 'oligase' since it hydrolysed cellodextrins with degrees of polymerization 2–6 but longer chains weakly or not at all. The other termed a 'polyase' hydrolysed cellodextrins and cellulose. The activities of the two components overlapped at the cellohexaose level. A similar separation has been achieved in *Aspergillus niger* preparations by gradient elution from anion exchange columns[30]. The oligase components appear to be similar to the cellobiase reported recently to occur intracellularly in *Stachybotrys atra* mycelium and to hydrolyse cellodextrins up to degree of polymerization 11, but not sodium carboxymethylcellulose or alkali swollen cellulose[31]. A polyase component with chain length specificity resembling Whitaker's *Myrothecium* preparation has already been studied in *S. atra*[32]. The scheme of cellulose depolymerization in these fungi might then be :

$$\begin{tikzcd}
\text{cellulose} \arrow[r] \arrow[rr, bend right, dash, "\text{polyase}"'] & \text{cellodextrins} \arrow[r] \arrow[r, bend left, dash, "\text{oligase}"] & \text{cellobiose}
\end{tikzcd}$$

The synergistic action between the two components would lead to a very rapid depolymerization.

The turnover number of Whitaker's *Myrothecium* enzyme[27] reached a maximum value at degree of polymerization 4, and below this value the activity dropped off rapidly, suggesting that the upper limit for the combining site of substrate with enzyme was about four glucose units long, which closely resembles observations made with respect to the combing site of iso-maltodextrins for antibodies against dextrans[33]. *S. atra* cellobiase splits off glucose units from the end of the dextrin[34], and its activity is independent of chain length over the range of cellodextrins tested (up to degree of polymerization 11). The combining site here may only involve one cellobiose unit at the chain end, so that the length of the chain would not influence the activity until it became long enough to create difficulties in the orientation of the chain end with respect to the active site.

The depolymerization of β-1 : 3 glucans requires specific enzymes and it has been possible to separate β-1 : 3-ase activity from the poly-β-1 : 4-ase activity in *A. niger* preparations either by chromatography on calcium phosphate or anion exchange resin columns[30,35]. This linkage specificity was considered by Ploetz and Pogacar[36] in explaining kinetic data obtained with *Helix pomatia* preparations; they, however, favoured an interpretation based on the presence of a non-specific oligase and polyase which could hydrolyse β-1 : 4, 1 : 3 and 1 : 6 linkages.

Following the elucidation of the structure of lichenan we are in a position to re-evaluate some of the findings of earlier workers who regarded lichenan as another form of cellulose. It is possible that both 1 : 4 and 1 : 3 hydrolysing enzymes would degrade this polymer provided that the presence of adjacent linkages of the other type do not restrict the hydrolysis. The 'lichenase' activity of *A. oryzae* can be fractionated[37] by precipitation with ether-alcohol mixtures into a fraction with activity on lichenan but not on cellulose and two fractions with activity towards both substrates. The activity-*p*H curves for the two substrates are very different and show multiple optima. These observations can be interpreted in terms of separate enzymes, one specific for 1 : 4 linkages and the other specific for 1 : 3 linkages. However, recent observations using the separated components of the *A. niger* preparation[30] have shown that only the poly-1 : 4-ase and the β-glucosidase components hydrolyse lichenan. The presence of 1 : 4 linkages on either side of the 1 : 3 linkages apparently prevents their hydrolysis by the 1 : 3-ase.

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VISUAL PIGMENTS IN THE COLOUR BLIND

By DR. W. A. H. RUSHTON, F.R.S.

NEARLY all colour-blind subjects confuse red and green, and the most extreme cases are dichromats, which means that they can match every colour of the spectrum with a mixture, say, of red and blue. But these dichromats are of two sharply different kinds, for the 'protanope' is insensitive to light of long wave-length and needs a very bright red light to match a moderate green, whereas the 'deuteranope' is nearly normal in his appreciation of relative brightness throughout the spectrum. Now when we plot upon the colour triangle those hues which the dichromats confuse, the points fall upon concurrent straight lines. For example, the protanope confusion loci radiate from the red corner of the colour triangle and, as Helmholtz and Maxwell pointed out long ago, this supports the view that the red 'mechanism' is absent. For this reason, protanopes are often called 'red blind'. The deuteranope lines are more nearly parallel to the red–green side of the triangle, so the name 'green blind' is less obviously applicable, and Pitt[1] has favoured the possibility suggested by Helmholtz that no sensation is lost but that red and green are fused. I have always had difficulty in grasping clearly what was the kind of thing which might in the deuteranope either be lost or fused. But now I wish to propose the view that there is both loss and fusion. What is lost is one class of cone, namely, that which in the normal is 'green-sensitive'; what is fused is the visual pigment, for the only non-blue cone which the deuteranope possesses contains the red- and green-sensitive pigments mixed together.

The pigments in the cones may be measured upon the fovea (which is rod-free) by the method of reflexion densitometry (Rushton[2]). When this is done in the red–green region of the spectrum with a protanope subject, one pigment is found. Fig. 1 shows its difference spectrum (the change in absorption after photolysis produced by shining a very bright light into the eye). The difference spectrum is the same with partial photolysis from red or from green light; hence only one visual pigment is present. If this is the pigment serving protanope vision, the curve might be expected to correspond to his daylight spectral visibility, just as twilight visibility corresponds to the absorption spectrum of rhodopsin (= visual purple).

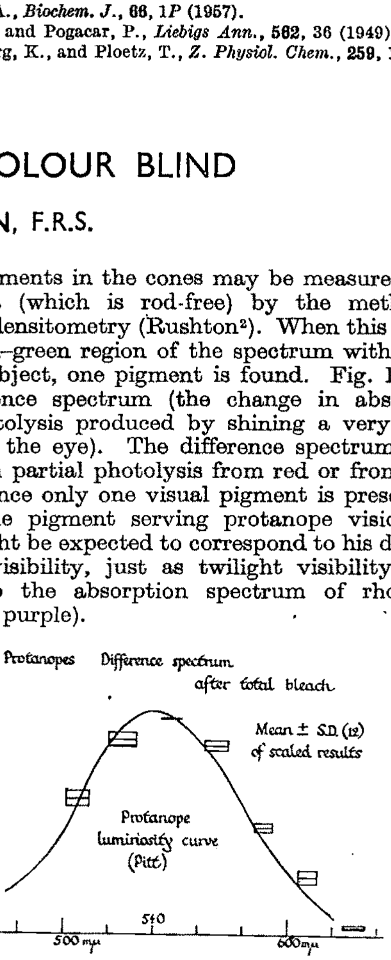

Fig. 1. Difference spectrum in the protanope, that is, the change in the logarithm of the reflectivity of the eye for light of various wave-lengths when the visual pigment has been bleached away by strong light

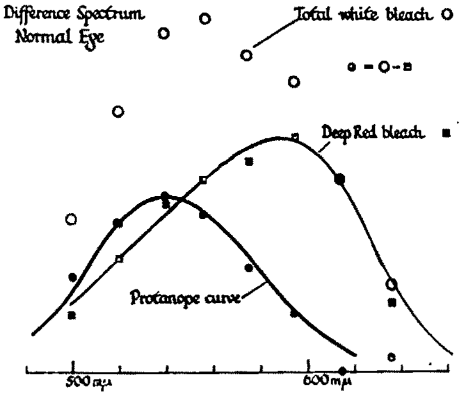

Fig. 2. Pigments in the normal eye analysed by bleaching with coloured lights. The total pigment is made up of chlorolabe and erythrolabe in the proportions shown. There is about twice as much chlorolabe in the protanope as in the normal

The curve of Fig. 1 is, in fact, Pitt's[1] protanope visibility, so it seems clear that protanopes can see only one colour in this half of the spectrum because they possess only this one visual pigment with absorption there. In contrast, Fig. 2 shows the results of partial photolysis of the normal fovea using red and green lights. This reveals two distinct pigments. One is the pigment of the protanope but in rather small amount; the other is a pigment which absorbs maximally at about 590 mμ and predominates. This latter pigment may be named 'erythrolabe' (= red taking), the protanope pigment 'chlorolabe', and the blue-sensitive pigment which does not here concern us, 'cyanolabe'. The protanope is known to have the normal number of cones in his fovea and normal acuity in his vision. Clearly, his loss is that none of his cones contains erythrolabe, but all are filled instead with chlorolabe.

A symmetrical situation would be to suppose that the cones of the deuteranope contained nothing but erythrolabe, but that is not true. Not only is the deuteranope visibility curve Fig. 4 (from Pitt[1]) very different in shape from the difference spectrum of erythrolabe, but also partial photolysis with a red or green light reveals (Fig. 3) that both erythrolabe and chlorolabe are present. Thus, the deuteranope visibility is monochromatic in the red–green, not because he lacks either of the normal pigments, but he mixes the information which separately they could give. This might be because the pigments are mixed in a single class of cone, or because the cone signals are mixed in a single class of nerve. The following two experiments point rather to the former explanation.

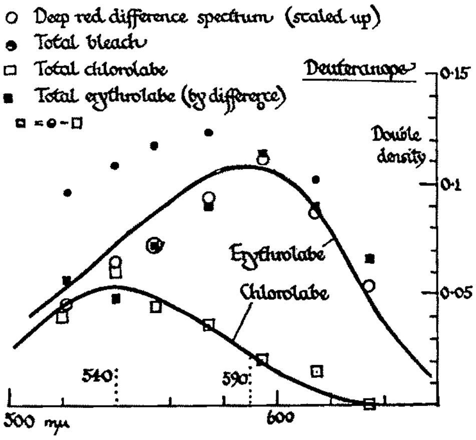

Fig. 3. Pigments in the deuteranope in correct proportions. Erythrolabe estimated by difference in total bleach (squares) and directly by bleaching with deep red light (circles)

A 4° circular field was made up of seven parallel strips of alternate green and magenta light, the blue and red of the magenta being separately adjusted by the deuteranope so that all seven strips appeared identical to him. Now a deep red field was superposed uniformly over the whole 4° of matching strips, and increased in intensity up to the point where the 4° circle was no longer visible. At no stage did the green appear different from the magenta; nor did any difference appear when a bright green field instead of a red one was uniformly superposed.

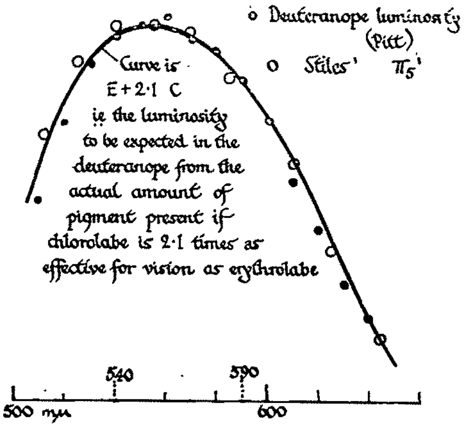

Fig. 4. Deuteranope luminosity curve (dots) from Pitt. Stiles's red sensitive mechanism π_5' (circles). The curve is the expectation from the pigments found in the deuteranope if chlorolabe is 2·1 times as effective for vision as erythrolabe. π_5' is the high-intensity form of π_5 (see Stiles, ref. 4)

When I myself looked at the circle through the strong green superposition, the green stripes were scarcely noticeable, but the magenta stripes stood out brightly. The reverse was the case when red light was superposed, and it was hard to believe that the deuteranope could find the two sets of strips equal. But his repeated settings of the red intensity for a complete match showed a divergence which was certainly less than 5 per cent when red, green or no fields were superposed.

In the second experiment, the 4° circle was half green and half magenta of the shade which exactly matched it for the deuteranope. A small point of light, either red or green, was flashed upon either one half of the field or the other, the flash being 10 msec. in duration and repeated once per sec. If the threshold for a green flash upon a red field is denoted (G/R), it was found that the ratios $(G/G)/(G/R)$ and $(R/R)/(R/G)$ were each nearly unity, and their product was exactly unity. For my (normal) eye it was about 8.

These two experiments prove that whatever is mixed in the deuteranope is mixed peripheral to that place in the retina where light adaptation occurs, and before the site where the cone signal becomes a somewhat logarithmic function of the light intensity. It appears, therefore, to arise peripheral to the place where the electroretinogram is generated, which Brindley[3] locates at the rods and cones. So, if we accept this, the deuteranope has his pigments mixed in a single class of cone. We cannot say in advance what is the relative efficacy of erythrolabe and chlorolabe in producing a nerve signal, but we may deduce it by noting how greatly the chlorolabe curve of Fig. 3 must be scaled up so that when added to the erythrolabe curve it will correspond to the deuteranope visibility curve ; the factor is about 2. The curve of Fig. 4 gives the combined effect of erythrolabe and chlorolabe so estimated, and is seen to correspond well with Pitt's visibility curve (dots).

In work extending over twenty years, Stiles[4] has investigated colour mechanisms in normal subjects by measuring the increment thresholds of flashes of one colour upon the background of another colour—a method crudely followed in my deuteranope experiment described above.

In the red–green region of the spectrum, Stiles has found two quasi-independent colour mechanisms labelled π_4, π_5, of which π_4 has nearly the same spectral sensitivity as the protanope (Fig. 1) and π_5 as the deuteranope (Fig. 4, circles). We may say, then, that the normal red–green colour mechanisms are reduced in the dichromat as follows : protanopes have only π_4, deuteranopes only π_5. But from our analysis of the foveas of these dichromats the nature of π_4, π_5 in the normal eye may now be stated. For π_4 is the response of the green-sensitive cones which contain only chlorolabe and the sensitivity of which corresponds to the chlorolabe spectrum. π_5 is the response of the red-sensitive cones which contain mixed pigments and the sensitivity of which does not correspond to the erythrolabe spectrum. The physical proportions in which the two pigments are mixed are shown in Fig. 3, but since chlorolabe is twice as effective as erythrolabe in exciting vision, we should increase its scale proportionally in all problems where we turn our analysis from pigments to sensations.

[1] Pitt, F. H. G., *Proc. Roy. Soc.*, B, **132**, 101 (1944).
[2] Rushton, W. A. H., *Nature*, **179**, 571 (1957).
[3] Brindley, G. S., *J. Physiol.*, **134**, 360 (1956).
[4] Stiles, W. S., *Docum. Ophthal.*, 3, 138 (1949). Coloquio Sobre Problemas Opticos de la Vision (Madrid), 1, 65 (1953). *Proc. U.S. Nat. Acad. Sci.* (in the press).

A BOREHOLE TO THE EARTH'S MANTLE?

By DR. T. F. GASKELL

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THE Mohorovičić discontinuity is the boundary between the mantle and the assorted surface rocks of the Earth, and it marks a very sharp change in the velocity with which earthquake waves travel—a jump from about 21,000 ft./sec. to 27,000 ft./sec. The mantle extends about half-way to the centre of the Earth, and encloses a core which earthquake seismic waves demonstrate to be fluid. At last year's meeting of the International Union of Geodesy and Geophysics at Toronto a resolution was passed urging the importance of drilling a bore-hole deep enough to penetrate the rock layer that lies below the Mohorovičić discontinuity.

The use of artificial earthquakes has been common practice for many years now in studying the Earth's crust. The seismic prospecting methods used to locate underground oil reservoirs tell the approximate depth and the shape of the surface of the underground layers of rock, but they do not give a firm indication of the type of rock. In order to draw an unambiguous picture of the sub-surface geology, it is necessary to follow particular rock layers from their surface outcrops, or from bore-holes. The layer below the Mohorovičić discontinuity does not come to the surface and therefore it is necessary to drill in order to find out what is the material—what chemical or radioactive properties it has—that forms the Earth's mantle.

It is found that the mantle lies at a depth of about 20 miles under the land, but that underneath the deep oceans it is only about 7 miles below sea-surface. The nearest the mantle comes to the surface of land is under oceanic islands, and here it is depressed below normal oceanic level to about 10 miles below surface. This is probably the best place to drill the hole to the Mohorovičić discontinuity.

The seismic measurements in the oceans enable estimates to be made of the thickness of sediment that has collected and compacted over millions of years on the sea-bed. As with oil-finding seismic work on land, the support of an outcrop or a bore-hole is needed to make an unambiguous interpretation of the measurements. In particular, there is a hard layer, lying beneath about 1,500 ft. of soft sediment, which could be a band of cemented limestone, or a continuous layer of volcanic rock. Beneath this again is a layer of rock which is probably the primeval ocean floor. The seismic measurements combined with analyses of volcanic material erupted from inside the Earth give some idea of what this rock might be, but they are only guesses because the exact origin of the molten lava of the volcano is not known, and in any event mixing will occur as the lava is forced upwards. A second recommendation was therefore made at Toronto—to drill a few thousand feet through the sediments that cover the three-mile deep oceans to see both what kind of rock lies beneath them and to collect samples all the way down in order to elucidate the depositional processes that have been going on in the past.

The deepest hole so far drilled is just over four miles. This hole, like most deep borings, was drilled to find oil—and it is to the oil industry that we owe most of the recent developments that have taken place in drilling. The total depth drilled is now well over a million miles, and last year in the United States alone 40,000 miles of oil wells were drilled—enough to go several times right through the Earth. Since 1927 there has been a steady increase, from 8,000 ft. to 22,000 ft., in the depth of the deepest hole.

Most modern oil-well drilling is carried out by the rotary method. It is difficult to appreciate the enormous length of pipe which is used to rotate the cutting tool at the bottom of the hole. To give an idea of the scale, a 33-ft. long wire, of 7/1,000 in. diameter, has about the same length-to-diameter ratio as a 20,000 ft. length of 4-in. drill-pipe. The cutting tool cannot be forced into the rock by pressing on such a long flexible length of pipe because the pipe would buckle. The tool is therefore driven into the rock by about 20–30 tons of extra thick pipe at the bottom of the hole, and the main length of the drill-pipe supports and rotates this bottom section. Without the heavy rigid section the drill-pipe bends, and the friction between the drill-pipe and the bore-hole almost stops the rotation; furthermore, the bit tends to go crooked. With a heavy section at the bottom, the thin drill-pipe is held in tension and the rock is penetrated quite readily. The motive power for the bit would be better at the bottom of the hole, and electric motors have been tried but without great success. It is difficult and perhaps dangerous to handle the large electric power needed, with cables that are subjected to the wear and tear of running in and out of a bore-hole.

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* Substance of a Royal Institution Discourse entitled "Drilling Deep Holes in the Earth", delivered on June 11.

Much more commonly used is a multi-stage turbine motor, which is driven by mud and water pumped down the drill-pipe and up the space between the drill-pipe and the walls of the hole. The driving motor consists of a hundred rotor elements, which give enough power to rotate the bit many times faster than the conventional rotary systems. The friction of the drill-pipe all the way down the walls of the bore-hole limits the rotary drilling speed to about 120 rev./min. High speed of rotation means correspondingly faster rock penetration; but apart from this, light-weight drill-pipe can be used, since it only carries the weight of the turbine, and does not have to twist it around; and, since the pipe is not rotated, there is very little wear on the sides of the bore-hole. Furthermore, if the cutting bit jams on an extra tough piece of rock, the turbine will be halted but the mud will circulate and keep the hole free. With the rotary drill, jamming of the bit often means that the drill-pipe is twisted until it breaks off.

The turbo-drill has another potential advantage which has not yet been realized. Because the drill-pipe is not rotated, the turbo-drill may be made to alter course by setting the axis of the drill at a few degrees to the drill-pipe with an elbow joint. There is no reason why this process could not be in some way controlled from the surface, so that the drill could be virtually steered in any direction. This is a desirable feature, because sometimes it is necessary to drill holes that are deviated sideways; for example, when producing oil from strata below a town where drilling would be inconvenient. However, it may also be the means of speeding up rate of drilling. The rate of penetration of the drill is approximately proportional to the weight which is allowed to press on the bit at the bottom of the hole; but there is a limit to the weight because in a narrow bore-hole the weight must be distributed over a length of heavy drill-pipe. Any slight bending of the pipe causes the drill to go off course, and this effect is often accentuated by the non-uniformity of the rock strata. If the drill can be steered along the true course, then we can press harder on the drill bit while still keeping straight and thus penetrate the rock correspondingly faster.

Even if we could drill very fast indeed, we should still have to spend time every now and again pulling up all the drill-pipe to renew the drilling bit when the cutting teeth became worn, or when the roller bearings which support the toothed wheels seize up. The time taken to unscrew and stack a few miles of drill-pipe is several hours. Much engineering development has gone into improving the life of drilling bits, and a recent advance has been to construct a bit which can be folded up and pulled up the inside of the pipe on a wire, so that a replacement can be lowered to carry on drilling without any need of removing the pipe itself from the hole. It is obviously much faster to wind up a wire on a drum than to unscrew all the pipe. This device is in its infancy, and a more revolutionary approach is to speed up the actual pulling out and unscrewing of the drill-pipe by means of a double hydraulic lift. The first lift raises a length of pipe, then the second lift raises the next section while the joint is being unscrewed and the first length of pipe is being stacked away. The first lift now goes down to catch hold of a third length of pipe and so a continuous hand-over-hand process goes on. These improvements in complete automation of pipe handling will not only save time and labour on the rig, but they will also give more carefully controlled operation. Automatic drillers are in fact coming into common use, and the servo system will be even better when used with smooth hydraulic feed instead of lifting by cable. The driller's job is not made less important, however; in fact, it is becoming more skilled and technical with each new advance. One of the problems that requires expert knowledge is the behaviour of the mud that is circulated down the drill-pipe and which flows up the space between the pipe and walls of the hole, carrying with it the fragments of rock that have been cut by the bit. These chippings must be removed, and only recently have laboratory experiments shown that very rapid removal of the chippings is important. Almost as much work must be done to grind up a chip as is required to form the chip from the parent rock in the first place. For efficient drilling, then, a chip must be removed before the next cutting tooth of the bit reaches it. Special outlets are made in modern drill bits to direct a stream of mud in the right places to do this. In order to carry the rock chippings to the surface, the mud must move at a few feet per second, and in order to minimize the pump power required the viscosity of the mud must be kept down.

However, the mud has other jobs to perform, and the final mixture is usually a compromise. In the first place, the mud must not settle out into its constituent parts if left standing, because if it did, the solid material sinking to the bottom would jam the drilling tools in the ground. A mixture of ground-up shale and water separates out into its constituent parts, but the addition of a small proportion of bentonite clay maintains the shale particles in suspension and so turns the mixture into a drilling mud.

Ideally, a thin layer of dried mud cake forms over the walls of the bore-hole, and in this way preserves the mud from contamination with any soluble compounds in the rock that is being drilled. At the same time, the mud cake on the walls of the hole gives strength to resist crumbling of soft materials such as clays and shales. The weight of the mud column itself holds back the walls of the hole from caving, in much the same way as pit-props support the roofs of coal mines. A good mud has almost jelly-like properties to stop it settling and to hold up the rock chippings when drilling stops. However, it must also be easy to pump down the drill-pipe—and so must be thixotropic.

Not only does mud help to keep the walls of the bore-hole from collapsing, but it also holds back high-pressure fluids—which may be water, oil or gas—from entering the bore and causing trouble at the surface. It is unlikely that high-pressure gas will be encountered in drilling the 10-mile deep hole to the Mohorovičić discontinuity. Borings at Bikini and Eniwetok have already demonstrated that hard basaltic rock is reached at a depth of a few thousand feet, and seismic measurements have suggested that this basaltic rock continues uniformly to the 10-mile depth of the Earth's mantle. This tough basaltic rock will not need a protecting wall of mud because it is rigid enough to stand up securely on its own. The top part of the hole, which will pass through possible loose and porous coral rock, can be walled off with a strong steel casing. The main part of the hole will, however, present new problems, and in some ways these may be more akin to those met in gold prospecting than in looking for oil. Oil is not found in hard igneous rocks, and normally these are not encountered in oil-well drilling. On the other hand, bore-holes up to 6,000 ft. in length have been drilled in order to assess the potential of gold-bearing quartz strata. It is possible that water will suffice instead of mud as our circulating fluid. Some form of circulating fluid will almost certainly be needed, because although the rock may stand up without the assistance of a hydrostatic column, some cooling and lubricating of the drill bit will be required. The temperature ten miles deep is expected to be anywhere between 400° and 700° F. The pressure of the water column will prohibit boiling down the hole, but it will be necessary to cool the water when it reaches the surface. There will be no fundamental difficulty in this; in fact, it might be possible to circulate sea-water. The most likely site for the bore-hole in order to encounter the Mohorovičić discontinuity at as shallow a depth as possible will be on the edge of a coral atoll, so that sea-water will be one commodity in ample supply.

Rock-drilling in mining is often carried out using diamond bits, and the hard basalt that will be met in a deep bore-hole will probably best be cut in this way. With the high-speed rotation of the turbo-drill it might be possible to increase the normal rate of a few feet an hour to, say, ten feet an hour. At this rate it would take more than two hundred days drilling to penetrate 50,000 ft. of rock. The time taken to pull out and renew the drilling bit may be greater than this. At present rates, the complete in-and-out round trip would take more than 30 hr. with the hole at its deepest, but it may be possible to achieve a factor of three with the new automatic hydraulic lifts that are now being developed. The life of a bit in very hard rock may be only equivalent to 50 ft. of drilling, so that there will possibly be a thousand trips in and out of the bore-hole. Even with the fast automatic pull-out, the time taken will be at least as long as that spent drilling.

It is possible, of course, that a modern version of the old cable-tool type of percussion drilling with its rapid method of pulling the tools out on a wire rope may be more suited to the hard basalt rock. Pneumatic chippers have been very effective in the Sahara recently in drilling tough siliceous limestone.

It is not unreasonable to consider even more fanciful means of cutting rock when standard methods are only capable of penetrating a few feet an hour. One such method is that of burning a hole by means of a flame torch. This is used for the 50-ft. type of hole that is drilled for shot-firing in mining. Suggestions have also been made that hard tough rock might be successfully broken up by letting off explosive charges at the bottom of the hole. The loosened debris could be removed afterwards by conventional drilling methods. A small charge of an ounce or so should shatter about 6 in. of rock, and if a technique could be devised to fire a shot every few minutes a drilling rate of 10 ft. or so an hour could be achieved.

It is quite clear that considerable research work is needed to produce a workable method of drilling the 50,000 ft. hole down to the Mohorovičić discontinuity, but the type of research work required is, in fact, already proceeding as part of the normal progress of oil-well drilling and rock mining. For example, the correct operation of the diamond cutter has been shown to depend on careful control of mud circulation and weight, and a factor of ten in distance of rock penetrated before the bit wears out may soon be possible. After all, diamond is tougher than the rock it cuts, and theoretically need not wear at all. In the opinion of most of those engaged in the industry, the problem of drilling to the Mohorovičić discontinuity could be successfully tackled now if the money for the project is forthcoming. The most promising method seems to be a combination of diamond bit with turbo-drill and fully automatic lifting mechanism, using sea-water circulation. The research effort to make the necessary improvements in the various components of this scheme would undoubtedly be repaid by speeding up normal oil-well drilling, just as motor racing has helped to produce better vehicles for everyday use.

The second deep drilling problem—that of drilling a few thousand feet through the sediments of the ocean bed—could be solved at once by using the techniques developed for underwater rock sampling off the California coast. Since 1953 a programme of geological investigation of this territory has called for many borings five or six thousand feet deep to determine the rock structures that exist beneath the sea-bed. In order to make these borings, a new technique was designed which permitted drilling from a floating vessel.

The motion of the vessel is taken up by gimbal systems and by sliding sections in the drill-pipe, so that drilling can proceed except in very rough weather. The barge is anchored to six mooring buoys and drilling is commenced through a string of casing suspended from the ship and clear of the ocean floor. After a few hundred feet have been drilled, the casing is cemented to the sea-bed, together with an assembly of valves and with guide-wires connecting to the ship, so that when the drill-pipe is pulled out it can be run back into the hole again.

In one trial a 300-ft. hole was drilled in a depth of 600 ft. of water without the complication of guide wires and well-head assembly at the sea-bed. The hole was drilled until the drilling bit wore out; then, since there were no guide wires it was impossible to find the hole again after pulling out to change the bit. However, it was possible to obtain samples of the rock that was drilled by cutting cores and pulling them to the surface in a cylinder lowered inside the drill-pipe on a wire line.

It is probable that this simple 'one-shot' technique would be adequate to drill through the soft sediments of the sea-bed to determine what is the underlying hard rock layer. There is very little wear on a coring bit when drilling clay, and the one bit should be able to penetrate all the soft material and at least a few feet of any hard layer. It may not be possible to anchor the drilling barge in 20,000 ft. of water, but it is possible to anchor a marker buoy, and the barge could be kept continually in position relative to the buoy with the aid of tugs. It will be most important, of course, both to choose a place where good weather is probable, and to have good weather forecasts, because the main hazard of the operation will be the possibility of losing 20,000 ft. of drill-pipe.

There is no reason why this technique of drilling in deep water should not be extended by the use of the folding up, retractable drilling bit. If the bit can be changed without pulling the pipe from the hole, there is no limit to the depth. Experience may even show that the full Californian off-shore method is practicable, using casing cemented into the rock of the sea-bed and guide wires to the surface, in which case a very interesting possibility presents itself. The Earth's mantle is only about 10,000 ft. below the floor of the ocean, and if it is possible to drill continuously in deep water the task of reaching the Mohorovičić discontinuity would be much easier than even from a coral atoll. In the first place, it is only about 30,000 ft. below sea-level in the deep oceans, and in the second, the top 20,000 ft. is water which does not have to be drilled. The technical difficulties do not appear to be insurmountable, especially if the turbo-drill rather than rotary is used. It is probably largely a matter of gaining experience with the easier project of the two discussed, and selecting a site for the experiment where there is the essential good weather and negligible currents.

HIGH-SPEED FLIGHT

At a time when the problems of the high-speed flight of aircraft, rockets and satellites are engaging the attention of scientists and engineers, it was very appropriate that Sections *A* and *G* of the British Association meeting in Glasgow on August 28 should devote one morning to lectures and discussion on this subject.

The subject was introduced by Prof. W. J. Duncan (Mechan professor of aeronautics and fluid mechanics, University of Glasgow), who underlined some of the vital principles behind these problems, showing that with the speeds that can now be attained the sharp distinction between the flight of aircraft and that of missiles has largely disappeared. The main engineering problems of high-speed flight can be grouped under four headings: (i) aerodynamic, (ii) kinetic heating, (iii) propulsion and (iv) guidance and control.

At supersonic speeds the shock-wave system around an aircraft causes an additional resistance (wave drag). One of the most important aims of the aircraft designer is to make this drag as small as possible. The problem of kinetic heating has given rise to the misnomer, 'the heat barrier'. The air in contact with the surface of the aircraft becomes heated, the effect being greatest at the most forward parts of the surface. Thus, when the speed of flight is 700 m.p.h., the temperature rise is 49° C., and this increases as the square of the speed.

The problem of propulsion depends upon the availability, or not, of atmospheric air. At extreme altitudes where the air density is very low, jet engines (for example, turbo-jets) can no longer be used and rocket propulsion has to be resorted to. Both jets and rockets have limited operational endurance (depending on the total fuel available); but whereas a turbo-jet gives a moderate thrust for a long time, a rocket gives a very large thrust for a comparatively short time.

Conventional controls are useless at altitudes where the air density is negligible. This can be overcome by using small jets to provide the moments required. The guidance of an unmanned missile may be provided by radar or by inertia navigation.

The subject was discussed in more detail in the two following lectures, the first of which, given by Mr. L. F. Nicholson (head of the Aerodynamics Department, Royal Aircraft Establishment, Farnborough), was on "Aerodynamic Aspects of High-speed Flight".

Mr. Nicholson defined the scope of the lecture as covering speeds "upwards from that of sound", the aim being to show the extent to which supersonic flight is becoming possible. For aircraft, one of the dominating factors in favour of high speed arises from the characteristics of jet engines, the thermodynamic efficiency of which increases considerably with speeds up to about five times that of sound. This increase in efficiency will be lost unless an efficient air inlet is used, which should also give low drag and avoid unstable pulsating flows; indeed, the air intake design can be one of the most exacting tasks of the design of a high-speed aircraft.

The aerodynamic efficiency was next considered. A measure of the efficiency of an aerodynamic shape for cruising flight is the ratio of the weight of the aircraft to the engine thrust required. Thus normal well-designed subsonic transport aircraft reach aerodynamic efficiencies of about 20. If such an aircraft were made to fly at supersonic speed by merely increasing the thrust, the efficiency would drop to about a tenth of its subsonic value (due to the unsuitable shape of the wings and fuselage for flight at supersonic speeds). This can be partially remedied by designing all parts of the aircraft to achieve full efficiency when operating in the flow field induced by the remaining parts of the aircraft; this has led to swept-back cambered wings and waisted fuselages. At speeds of the order of twice that of sound, a drop in aerodynamic efficiency is best avoided by using thin wing and tail surfaces and by drawing out the fuselage into a very slender shape. The wings themselves should be of large chord and of short span, with highly swept leading edges (having a plan form similar to that of a delta wing). The flow over such wings is highly complex, with separated flows springing from the leading edges at all incidences apart from that of cruising flight.

The kinetic heating problem mentioned above is mitigated to a certain extent by the effect of radiation, which increases rapidly with increase of temperature. By flying high, temperatures can be kept down to 600° C. at speeds five times that of sound.

Looking ahead to still higher speeds, a typical flight would consist of an accelerated climb (to a speed of the order of 10,000 ft. per sec.), followed by a long decelerating glide (for ranges of 2,000–3,000 miles), the aircraft being rocket powered. Sharp points and edges on the wings would have to be avoided as they would tend to become 'hot spots'. The energy of the fuel in such flights would be almost entirely used in building up the kinetic energy of the aircraft; thus a light weight would be more important than low drag. The weight of fuel used on a typical 3,000-mile flight need only be about twice that used in a cruising flight at supersonic speed; thus hypersonic gliders are not beyond the realms of economic sense in the long-term future.

At these speeds longer ranges can be obtained in ballistic flight mainly outside the atmosphere. Here the problem of high temperatures and loads on re-entry to the atmosphere is indeed a frightening one. However, much of the kinetic energy of the motion could be diverted into heating the air in the wake rather than heating the aircraft. The best way to avoid excessive heating would be to allow the missile to follow a shallow trajectory on re-entry, using aerodynamic lift to increase the re-entry time from seconds to minutes. The increased time would allow radiation effects to dispel any excessive heating.

The final lecture, given by Mr. E. C. Cornford (head of the Guided Weapon Department, Royal Aircraft Establishment, Farnborough), was on "General Aspects of Travel at Very High Speeds with Special Reference to Rockets and Satellites". Mr. Cornford discussed the general propulsive and structural requirements of long-range ballistic vehicles and satellites, together with the problems of their guidance and control.

The flight pattern of a long-range rocket or satellite generally consists of a short period of powered flight during which the missile climbs out of the Earth's atmosphere. At the end of this stage the missile velocity ('all burnt' velocity) might be 22,000 ft. per sec. or more for a range of some 3,000 miles. The mass ratio (mass at launch/mass at 'all burnt') for such a single-stage rocket would be about 14. Thus only about 7 per cent of the initial weight of the missile is left for the payload, structure, motor, guidance and control systems, as well as any of the propellants which remain unused.

The position is much improved if a multi-stage rocket is used, that is, a missile in which two or more rockets are fired in succession, and as each burning stage is completed the empty propellant tank and propulsion unit are discarded. Thus a two-stage missile, each part having a mass ratio of 5, gives almost the same velocity as a single stage of mass ratio 25.

The main structural problem of a long-range rocket or of the launching vehicle for an Earth satellite is in the design of the integral propellant tanks, which are thin-walled cylindrical shells designed to withstand compressive end-loads (from the motor, missile inertia and drag), shear forces and bending moments (from the guidance system) and internal pressure. The thin walls of these tanks may be stabilized by internal pressurization or by mechanical means or by a combination of the two methods. The materials used need to have a high specific strength and stiffness and the ability to maintain these properties over a wide range of temperatures.

Much experience has been acquired relating to the use of liquid oxygen/kerosene systems. Possible improvements in rocket performance would be obtained by using various combinations of the oxidants (liquid oxygen, ozone and fluorene) and the fuels (liquid hydrogen, ammonia, hydrazine and the boron hydrides) to increase the specific impulse. It is questionable whether the gain in the specific impulse obtained in this way is worth the engineering effort required to make use of these liquids, almost all of which are either toxic or corrosive or liable to detonation. Recent developments with solid rocket propellants have led to specific impulses approaching those of current liquid propellants. Solid propellants greatly simplify the engineering problem, but the associated structure weights are appreciably higher. Nuclear rocket propulsion offers means of enabling space travel beyond the capabilities of conventional rockets.

The accuracy with which a long-range ballistic rocket will reach its target or with which an Earth satellite achieves a planned orbit will depend on its position and velocity at the end of its propulsion. For a ballistic rocket by far the most severe requirement is that for velocity accuracy along the trajectory at 'all burnt'. The guidance requirements for Earth satellites are likely to vary greatly with the purpose for which the satellite is intended; at present any orbit within rather wide limits is a success.

Guidance of rockets or satellites consists of the determination of the position and velocity during its powered flight, and of computing the corrections to be made to the flight path to achieve the required terminal conditions. There are, in general, two types of guidance: (i) radar measurement of position and velocity; and (ii) measurement of acceleration by means of an inertia navigator in the missile. With radar guidance systems there is the problem of noise in the system (due to variations in motor thrust, in the measuring system itself and to ionization in the rocket flame). The centre of an inertia guidance system for a long-range rocket or a satellite is the space-stabilized inertia platform, carrying three orthogonally mounted accelerometers. The main problem with inertia guidance systems is in the design of gyroscopes and accelerometers of sufficient accuracy and stability of performance. The wander of the gyroscopes can be minimized by using a flotation gyroscope. The error characteristics of the radar and inertia guidance systems are to some extent complementary. The radar system has excellent long-term stability but suffers from noise at higher frequencies, whereas the inertia system has little high-frequency noise but suffers from long-term drift.

The main function of the control system of rockets or satellites is to apply the corrections given by the guidance system to the flight path. The couples necessary to change the attitude of the missile are usually produced by deflecting the efflux jets from the main motors or by movable vanes in the jet. The control problem is complicated by any flexibility of the structure and by fuel sloshing.

In the subsequent discussion many points were raised in connexion with re-entry into the atmosphere. One speaker thought that re-entry to the denser air should be achieved as quickly as possible, the resulting heated external surface being effectively insulated from the interior of the missile. As pointed out by Mr. Nicholson, this would be doubtful from a practical point of view. Heat transfer is more severe under normal flow conditions. Powered deceleration is ruled out because of the additional fuel required. Re-entry by 'skip' would be of advantage in giving more time for the cooling of the missile but would create many problems in guidance and control.

The audience were left with the impression that there are no insurmountable technical barriers to be encountered in this field, although the practical difficulties of attaining the objectives seem formidable.

A. W. BABISTER

OBITUARY

Dr. Malcolm A. Smith

Dr. Malcolm Arthur Smith, a well-known authority on amphibians and reptiles, died at his home at Ascot on July 22 at the age of eighty-two.

He qualified M.R.C.S., L.R.C.P. in 1898 at Charing Cross Hospital and remained there for four years as house physician and surgeon before going to Siam, where he took up an appointment as medical officer to the British Legation in Bangkok. For almost a quarter of a century he practised medicine in Bangkok, during which period he acted as physician to the Court of Siam. He was one of the very few Europeans to come in contact with life at the Court and to have first-hand knowledge of its organization. On his return to Britain he wrote an interesting account of the remarkable happenings in the lives of the royal family which was entitled "A Physician at the Court of Siam", published in 1947.

His interest in herpetology gathered momentum as his zoological expeditions to the interior of Siam, Indo-China and Malay produced more rich and valuable collections, and he devoted more and more of his leisure time to the study of the Oriental species. He was an acute observer and a prolific writer, having more than a hundred publications to his credit. Most of these were based on classification and structure, although, more recently, he turned to considerations of evolutionary changes in the ear and the eye-covering of lizards, in snake dentition and in the head glands of snakes. His taxonomic studies reached a climax in an outstanding monograph on sea snakes and in the three volumes on the crocodiles and tortoises, the lizards, and the snakes, published in the "Fauna of British India" between 1931 and 1943 and after he had retired from Siam and had become an honorary associate of the British Museum. During the last decade or so of his life he committed himself to a study of the reptiles and amphibians of Great Britain, acknowledging with a wide comprehension the problems that were still unsolved or unpublished in that field. He became the author of yet another outstandingly successful book, "The British Amphibians and Reptiles", which was immediately recognized as a comprehensive and thoroughly reliable account of the structure, habits and behaviour of our British species. This is a book that is an invaluable guide to the specialist besides providing enjoyment to the layman, and it has become the standard work on the subject.

Not only an account of his scientific works shows him to have been an experienced and energetic personality, but the posts he held also indicate the zeal and devotion he gave to the advancement of herpetology. He was the first president of the British Herpetological Society from its inauguration in 1947 until 1954, recorder for the Amphibia and Reptilia section of the "Zoological Record" from 1929 until 1945 and editor from 1938 until 1949, and zoological secretary to the Linnean Society from 1939 until 1948.

A. G. C. Grandison

NEWS and VIEWS

Commonwealth Advisory Committee on Defence Science

A meeting of the Commonwealth Advisory Committee on Defence Science is to be held in Australia during October 6–28. Sir Leslie Martin, defence scientific adviser to the Australian Department of Defence, will be the general chairman of the meeting. The Australian delegation will be led by Mr. W. A. S. Butement, chief scientist of the Department of Supply, and other delegations include Dr. J. E. Keyston, vice-chairman, Canadian Defence Research Board; Dr. D. S. Kothari, scientific adviser to the Indian Minister of Defence; Dr. Mohammed Afaf, Pakistan; Dr. S. M. Naude, scientific adviser, Department of Defence, South Africa; Sir Frederick Brundrett, scientific adviser to the United Kingdom Minister of Defence, Air Marshal Sir Geoffrey Tuttle, Deputy Chief of the Air Staff, and Dr. D. H. Black, director, Armament Research and Development Establishment. New Zealand will also be represented. These meetings are held at approximately three-yearly intervals and the last was in Canada in February 1956. The object of the Committee is to promote collaboration throughout the Commonwealth in the application of science to military affairs, and the meeting will be attended by senior defence scientists and senior officers of the armed forces of the Commonwealth.

Imperial Cancer Research Fund

Dr. J. Craigie has resigned his post as director of the Mill Hill laboratories of the Imperial Cancer Research Fund so that, free from administrative duties, he can devote himself entirely to research in the laboratories. His invaluable advice on problems of research will thus continue to be available to the Fund. Dr. R. J. C. Harris is joining the Fund's scientific staff on October 1 to take up a new appointment as head of the Division of Experimental Biology and Virology. He will also be responsible (under the director, Dr. G. F. Marrian) for the general administration of the Mill Hill laboratories. Mr. A. R. Currie, at present assistant pathologist at the Royal Infirmary, Glasgow, has been appointed head of the Division of Pathology, and will take up his duties on October 1, 1959. The Fund is meanwhile giving financial support to the cancer research he is undertaking in the Pathology Department of the University of Glasgow.

Transfer of Controlled Thermonuclear Project from Harwell

It is proposed to remove the whole of the controlled thermonuclear project from the Atomic Energy Research Establishment, Harwell, to Winfrith Heath, Dorset. This change will permit the development of both fission and fusion work at Winfrith, and allow room for whatever expansion of the latter is necessary in the future. It will also provide a margin for new work as yet unseen which will undoubtedly be developed at Harwell. Winfrith Heath, which is near Dorchester, is a new site taken over by the United Kingdom Atomic Energy Authority. When first announced it was said that it would be a "second Harwell" and that it would provide scope for work on reactor development. Development of the site started in September 1957, and one of the first projects is the construction of a high-temperature gas-cooled reactor.

British Ballistic Missile fired from Woomera

A British 'Black Knight' ballistic missile was successfully launched to a height of 300 miles from Woomera rocket range on September 7. The Australian Minister of Supply, Mr. Atholl Townley, who was at Woomera to see the launching, is reported to have said that the rocket performed according to expectations. The 'Black Knight' is a purely research vehicle, and observations of the behaviour of the rocket engine, control and guidance mechanisms, together with measurements of its environment and other phenomena, were made continuously while it was in flight and relayed to ground receivers from several transmitters installed in the missile. Its behaviour during re-entry into the Earth's atmosphere was also recorded; the nose-cone has been recovered. The 'Black Knight', which is about 35 ft. long and 3 ft. in diameter, was largely developed and built by Saunders-Roe, Ltd., in co-operation with the Royal Aircraft Establishment. Static firings were made at Highdown, on the western tip of the Isle of Wight. The rocket engine was built by Armstrong-Siddeley Motors, of Coventry, to an original design of the Rocket Propulsion Department of the Royal Aircraft Establishment at Westcott.

Swedish National Committee for Physics

The ninth general physics conference of the Swedish National Committee for Physics was held at the University of Uppsala during June 3–5, 1957, and a brief report of the meeting together with abstracts of the large number of contributed papers is printed in the March issue of *Arkiv für Fysik*. (13, 251; 1958). Guest lectures were given by M. A. Melvin (Florida State University), who spoke on conservation-invariance principles and the behaviour of elementary particles, and by H. Palevsky (Brookhaven National Laboratory), who discussed the use of cold neutrons to investigate the solid state.

The majority of the contributed papers deal with aspects of nuclear physics, but there were several survey articles or lectures of general interest. H. Conde discussed the generation and measurement of high thermal radiation intensities, and E. Djurle and W. S. Rodney instrumentation for phase contrast measurements in the near infra-red. A brief survey of present-day knowledge of the elementary particles and of their transformations was given by S. von Friesen, and an account of the proposed new physics building for the University of Stockholm, which is expected to be ready for use in 1959/60, by E. Hulthen. A description of the Uppsala Ionosphere Observatory was given by W. Stoffregen. Its geographical situation is near the auroral zone and instruments for ionospheric research and an all-sky aurora camera are in operation at the observatory. The ionospheric recorders, or 'ionosondes', designed and constructed at the observatory, consist of a radio pulse transmitter and receiver, together with oscillograph units for photographic recording of the radio echoes, and they make vertical soundings of ionized layers of the atmosphere. For study at oblique incidence by means of backscatter, a rotating beam antenna is used and reflexions up to 2,000 mk. distance can be received. Since January 1957, a secondary station has been in action at Lycksele, about 500 km. north of Uppsala, and six aurora cameras are also operating at places between Uppsala and Tromsö.

Institution of Metallurgists Handbook

During the first quarter of the present century, more metal was produced and used throughout the world than during the whole of previous historic time. This growth in the practice of metallurgy demanded a body of trained and qualified metallurgists. It is, however, barely a dozen years ago since the Institution of Metallurgists was founded to meet this need. Its first object is "to advance and co-ordinate the study and science of metallurgy in all its aspects". In so doing, the Institution clearly serves the public interest, not only by certifying the scientific or industrial qualifications of its members, but also by its work, for example, in connexion with National Certificates in its subject. That a need for such an Institution existed and that it is serving the purpose for which it was founded is abundantly demonstrated by the growth of its membership, a growth which surprises even the most sanguine of its founders.

In its new form, the Year Book and List of Members for 1957–58, published for the Institution by Batiste Publications, Ltd., gives expression to the increasing prestige which the Institution enjoys and deserves. In addition to the list of officers and members and the conditions under which admission to the various grades of membership may be obtained, 75 pages are devoted to short technical articles dealing with the more important of the individual metals. In the space available these articles cannot, of course, be exhaustive, but they are very far from being superficial and the data contained are authoritative. In a foreword, Mr. James Mitchell, the president at the time this handbook was prepared, summarizes the aims of the Institution, aims which in a large measure, at any rate, have been attained, in the following words: "The Council of the Institution are most anxious that its membership should include all practising metallurgists who have the necessary qualifications, but they are insistent that a high professional standard must be maintained and they take this to include not only technical qualifications and experience but the observation of high ethical standards".

Careers in the Medical Research Council

Under the title "Technical Careers in the Medical Research Council" (pp. 31. London: Medical Research Council, 1958), the Medical Research Council has issued a brochure giving a concise but clear picture of the opportunities which are open as technical officers or technicians in the service of the Council. The Council's staff of 2,152 (only 121 of whom are part-time) comprises 224 medically qualified, 424 scientifically qualified and 91 technical officers, with 690 other technical staff, 332 maintenance and 391 administrative and clerical staff. Besides information about the general conditions of service, a brief survey of the types of work undertaken in the Council's establishments and a note on the qualifications required for entry to the various grades, the booklet includes a survey of the research programme under the main scientific headings and an alphabetical list of the Council's establishments and their addresses, which make it useful to a wide range of scientific workers.

Technical Authorship

A SCHEME of instruction and examination in technical authorship, intended for those with engineering, technical or scientific training and experience, has been drawn up by the City and Guilds of London Institute Advisory Committee with the needs of the younger entrants in mind. The examinations will also be open to practising technical authors. The regulations and syllabuses are detailed in a pamphlet, "Technical Authorship", issued by the Institute (pp. 9. London: City and Guilds of London Institute, Gresham College, 1958. 9*d*.). A four-year part-time course of instruction is envisaged and the Intermediate examination of the Institute will be taken at the end of the second year and the Final examination at the end of the fourth year of the course.

Queen Victoria Museum and Art Gallery, Launceston

THE report for 1956–57 of this progressive Museum and Art Gallery records that the renovation programme has been continued. The main projects have been the complete reconstruction of the china room, the construction of new cases in the vertebrate gallery, improvements in the lecture room and additional storage accommodation. In association with the University of Tasmania, an expedition to examine the rock markings in the Blue Tier district was undertaken. It is suggested that these are aboriginal in origin. Also in association with the local field club, an exhibition of native plants was arranged and maintained for about three months. The engagement of a temporary assistant in the geological department produced considerable development in this sphere, and many improvements were effected.

The *Records of the Queen Victoria Museum*, New Series No. 9, includes an important paper on the Van Diemen's Land Company 1825–1842 by Mr. A. L. Meston (pp. 62. 1958. Launceston, Tasmania: Queen Victoria Museum). From a study of the wool trade in Britain and the increasing inadequacy of the supply of fine wool the work proceeds to the chartering of the Van Diemen's Land Company in 1825. Its grant was for districts outside the settled areas and its power confined to producing fine wool. The colonists, however, were suspicious of absentee monopolists, and the regions of land granted were quite unsuited to raising fine-woolled sheep. Stock losses were heavy from weather, wolves and aborigines. Finally, the management were unable to overcome the natural and official obstacles, and the Company closed in 1842. The paper forms an important side-issue of the early history of the wool trade in England.

Stable Graticules

MESSRS. GRATICULES, LTD., have recently introduced a new graticule process which they term 'maXta' (for maximum stability). It has the advantage that the graticule is composed solely of a noble metal on glass; there is no gelatine or other support material. The image is firmly bonded to the glass and is extremely resistant to abrasion, obviating the necessity for a cover glass. This is an important consideration, since breakdown in graticules is often associated with the cover-glass cement. Further, the absence of gelatine means that there is no suitable substrate for fungal attack—an advantage in tropical conditions. The method is based upon work commenced by the late Julius Rheinberg. It is essentially a photographic process and is most suitable for lines on a transparent ground rather than the reverse. The technique can be applied to most of the available glasses. Three types are made having varying optical qualities. These variations are associated with the adhesion rather than with the image quality, which in each case is very good. These graticules were developed in the course of work carried out at the British Scientific Instrument Research Association, Chislehurst, Kent.

Germination of Oil-Palm Seed

THE results of an interesting investigation of the factors controlling seed germination in the West African oil palm, *Elaeis guineensis* (Jacq.) have been given by G. Hussey (*Annals of Botany*, N.S., 22, 259; 1958). It is recorded that under natural conditions in West Africa, at the average ground temperature of 25–30° C., oil-palm seed germinates sporadically over a period of years, but with continuous heat treatment (38–40° C.) 50 per cent germination of either nuts or extracted kernels occurs within a few months. The kernel comprises a small cylindrical embryo embedded in a mass of oily endosperm which in turn is surrounded by a thick testa. At germination the testa and layer of endosperm covering the distal part of the embryo are forced out as a disk-like operculum which is already demarcated in the ungerminated kernel by a circular abscission zone in the endosperm cells. The excised embryo is non-dormant and at 30° C. starts to elongate within 24 hr., either on moist filter paper or while still in contact with the endosperm. At 30° C. removal of the operculum is followed by a sluggish emergence of the embryo in air; emergence at the normal rate occurs in pure oxygen, or in air if a long period at high temperature precedes deoperculation. Fresh intact kernels remain ungerminated for at least six months at 30° C., either in air or in pure oxygen. At high temperature (40° C.) intact kernels germinate faster in pure oxygen than in air; at 30° C. the same applies only after previous treatment at high temperature. This accelerating effect of oxygen is shown to be dependent upon the progress of slow processes stimulated by high temperature. It is postulated that germination of oil-palm seed is dependent upon a minimal threshold concentration of oxygen in the embryo and that during dormancy this minimal level progressively decreases at a rate depending on the temperature.

Harkness Fellowships of the Commonwealth Fund

THE awards which have borne the title of Commonwealth Fund Fellowships since 1925 are being offered for 1959 under the title of Harkness Fellowships of the Commonwealth Fund. The Fund is an American philanthropic foundation endowed by the late Mrs. S. V. Harkness and the late Mr. and Mrs. E. S. Harkness, for promoting international understanding by providing opportunities for education and travel in the United States. Fellowships tenable in the United States are offered in separate series in the United Kingdom, in Australia and New Zealand and in Western Europe. Thirty Fellowships are offered in the United Kingdom for 1959 to men or women who have not previously worked for more than a few months in the United States, and who are graduates or have experience in government service, the professions, the creative arts, journalism, branches of business or industry. Forms of application, which must be returned before December 2, can be obtained from the Warden, Harkness House, 38, Upper Brook Street, London, W.1, from whom further details can also be obtained.

Atom School for Business Men

Nearly three hundred company directors and similar executives have been to four-day courses organized by the Isotope School, Atomic Energy Research Establishment, Harwell, during the past year. These courses are designed to give delegates information about current and possible future uses of radioisotopes in industry. The Isotope School at Harwell is running a further course during September 23–26 which is open to any company director or similar executive. There are still a number of places available on this course. Delegates will be housed at Worcester College, Oxford, for four nights and taken daily to Harwell. There will be lectures and demonstrations and visits arranged to atomic reactors, the Isotope Division Handling Hall and the Wantage Radiation Laboratories, where research is directed towards initiating the commercial use of large-scale irradiation sources. Further information can be obtained from the Registrar, Isotope School, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

International Conference on Information Processing

An international conference on Information Processing will be held in Paris during June 15–20, 1959. The conference is being organized by Unesco with the help of a group of consultants from various countries. Persons who wish to offer a paper should send the title, with three copies of an abstract of about 250 words, to their national group before October 1. Abstracts must be submitted in English or in French (or be accompanied by a translation in one of these languages). Further information can be obtained from the Honorary Secretary, Group *B*—Computation and Automatic Control, British Conference on Automation and Computation, c/o The Institution of Electrical Engineers, Savoy Place, London, W.C.2.

University News : London

Dr. R. C. Curran, senior lecturer in the Department of Pathology of the University of Sheffield, has been appointed to the University chair of pathology tenable at St. Thomas's Hospital Medical School. Mr. M. de Burgh Daly, Locke Research Fellow of the Royal Society in the Department of Physiology at University College, has been appointed to the University chair of physiology tenable at St. Bartholomew's Hospital Medical College. Dr. P. L. Pratt, lecturer in physical metallurgy in the University of Birmingham, has been appointed to the University readership in physical metallurgy tenable at the Imperial College of Science and Technology. Dr. A. M. Cook, senior lecturer in pharmaceutics at the School of Pharmacy, has been appointed to the University readership in pharmaceutics tenable at that School.

Scientific Film Association

Owing to the continued growth in membership and the consequent increased demands on its services, the Scientific Film Association has moved to new offices in 3, Belgrave Square, S.W.1. These premises have been made available by Aslib, and it is anticipated that this closer relationship will introduce the work of the Scientific Film Association to many who are concerned with documented information of all kinds.

Announcements

Dr. Joseph Auer, head of the Department of Anatomy, Faculty of Medicine, University of Ottawa, has also been appointed assistant director of the Division of Medical Research, National Research Council of Canada, from August 1.

Prof. H. C. Darby has been appointed to fill the vacancy in the membership of the National Parks Commission created by the retirement of the Rev. H. H. Symonds.

Mr. N. S. Billington, who has been head of the National College for Heating, Ventilating, Refrigeration and Fan Engineering since February 1950, has resigned as from August 31, 1958, to take up the appointment of director of the Heating and Ventilating Research Council. Dr. David R. Scott, at present a senior lecturer on the staff of the Royal College of Science and Technology, Glasgow, has been appointed to succeed Mr. Billington.

The Corday-Morgan Commonwealth Fellowship for the year 1958/59 has been awarded to Miss Rama Bhattacharya, who has, since January 1957, been junior research fellow of the Council of Scientific and Industrial Research, India, at the University College of Science, Calcutta. It will be tenable in the Department of Chemistry, University College, London, under Prof. Sir Christopher Ingold. The Fellowship is not offered for the academic year 1959/60.

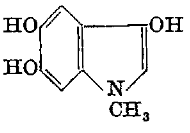
A conference on "Food and Farming : a Survey of Problems and Remedies" will be held, under the auspices of the Association of Agriculture, at the London School of Economics, on September 27. Further information can be obtained from the general secretary, The Association of Agriculture, 53 Victoria Street, London, S.W.1.

The Scottish Group of the Nutrition Society is holding a symposium on "Nutritional Hazards caused by Radioactive Contamination of Foods" in Edinburgh on September 27. Those interested, who are not already members of the Society, are invited to write for further particulars to Dr. J. Davidson, the Rowett Research Institute, Bucksburn, Aberdeenshire.

The Institute of Personnel Management is to hold a conference on "The Individual and the Organization in Modern Society" at Harrogate during October 10–12. Further details can be obtained from the Institute at Management House, 80 Fetter Lane, London, E.C.4.

A meeting of the Photoelectric Spectrometry Group will be held in Courtauld Hall, Queen Elizabeth College, Campden Hill Road, London, W.8, on October 17, at 2.30 p.m., when three papers dealing with spectropolarimetry will be read. Further information can be obtained from Mr. K. A. Macdonald, Arbury Works, 56, Arbury Road, Cambridge.

Erratum. In the communication entitled "Reduction of Adrenochrome with Ascorbic Acid", by Dr. R. A. Heacock and Miss B. D. Laidlaw, in *Nature* of August 23, p. 526, there is a misprint in formula V (adrenolutin) ; it should be



THE COUNCIL FOR NATURE

THE inaugural meeting of the Council for Nature took place in the rooms of the Zoological Society of London on July 12, when Lord Hurcombe delivered his presidential address. He emphasized that the Council has no intention of taking up an impracticable or hostile attitude towards developments necessary for the economic interests of Britain, but that nevertheless the preservation of natural life and resources is entitled to a high place in a civilized and highly populated country. Secondly, he felt that schemes involving biological devastation should be more seriously investigated than they sometimes were, and that necessity rather than convenience should be borne in mind. Further, while local and specialized societies are often engrossed with their restricted interests, they have a duty towards securing a state of public opinion that considers the interests of naturalists realistically. Indiscriminate chemical warfare on pests and river pollution by effluents show that a full realization of the problems has certainly not yet been achieved.

Lord Hurcombe appealed to all interested societies and authorities to join in making a concerted attempt to preserve the remaining resources of natural life in Britain, and gave assurances that the Council would encourage the establishment of Nature reserves and naturalists' trusts, and would co-operate so far as possible with the Society for the Promotion of Nature Reserves and with the Council for Field Studies. Finally, he announced that the Council for Nature is to have the honour and stimulus of the patronage of H.R.H. the Duke of Edinburgh. The meeting then proceeded to consider items of essential business. The draft constitution was adopted and the members of the executive committee elected.

The chairman, Sir Landsborough Thomson, described the functions of the three sub-committees that the Council proposes to set up. One will deal with conservation problems; another will concern itself with education; and the third will be for publicity and public relations.

Mr. Aubrey Buxton, honorary treasurer, then dealt with the proposal that a magazine should be published for the Council. This would certainly not be a house journal, but a popular journal aimed at a wide public with an interest in many aspects of natural history and the countryside.

One of the most important aims of the Council is to create a new interest in the countryside among school children and organized youth groups. Some of this interest could be guided into practical work in Nature reserves and other conservation projects.

After the business meeting, Mr. Tony Soper spoke of the work of the Natural History Unit of the B.B.C., explaining, with illustrations, many of the problems involved in filming and making sound recordings for natural history programmes. The secretary of the Council, which is now supported by more than a hundred societies, is Mr. D. J. B. Copp, 41 Queen's Gate, London, S.W.7.

THE ROYAL SOCIETY OF CANADA

THE seventy-sixth annual meeting of the Royal Society of Canada was held at Edmonton, Alberta, during June 2–4, under the presidency of Prof. Thomas W. M. Cameron, of McGill University. In celebration of the jubilee of the foundation of the University of Alberta under the presidency of the late Dr. H. M. Tory in 1908 and because Edmonton is the gateway to the north-west of Canada, a symposium was held on the "Potentialities of the North-West". The subject was introduced by Dr. C. H. Mackenzie, president of the Atomic Energy Control Board and past-president of the National Research Council of Canada. He was followed by Dr. R. F. Legget, director of building research, National Research Council, who discussed transportation and housing possibilities; by l'Abbé Antoine d'Eschambault, who dealt with the historic background; by Prof. W. C. Wonders, of the University of Alberta, who considered geographical problems; and Prof. D. Rawson, of the University of Saskatchewan, who spoke on biological problems of the region. The symposium was closed by Dr. D. B. Turner, Deputy Minister of Recreation and Conservation and Commissioner of Fisheries, British Columbia, who summed up the possibilities of northern British Columbia, the Yukon and the Mackenzie Valley.

Sectional symposia were also presented on "Oceanography" and on "Physical Methods in Organic Chemistry". In addition, papers were read in the various Sections of the Royal Society of Canada: mathematical, chemical, physical (under the presidency of Dr. Leo Marion); geological (under the presidency of Mr. H. C. Rickaby); and biological (under the presidency of Dr. W. R. Campbell).

Prof. Cameron's presidential address was on "The Evolution of Evolution". He noted that in the year of the founding of the University of Alberta, the Linnean Society had awarded Alfred Wallace a medal for the paper read fifty years previously, simultaneously with Charles Darwin, when the two naturalists introduced the subject of evolution by natural selection. Wallace had named the subject "Darwinism" and had left the field free for Darwin to develop further. As a result, Wallace's part was largely minimized or overlooked. Another man whose work had been misinterpreted, mistranslated and, to a great extent, overlooked, was Lamarck—discredited by Cuvier in France and both misrepresented and ignored elsewhere. It seemed obvious that few workers had read his original "Zoological Philosophy"; if they had, his part in the evolution of the theory would be much better understood. Other workers whose views had played a part in preparing the way for Darwinism were Buffon and Erasmus Darwin—the remarkable grandfather of Charles—as well as the geologists Hutton and Lyell. Prof. Cameron quoted Darwin's own views on this: "Species have been modified during a long course of descent chiefly through the natural selection of numerous successive slight, favourable variations: aided in an important manner by the inherited effects of the use and disuse of parts, and in an unimportant manner (that is, in relation to adaptive structures whether past or present) by the direct action of external conditions and by variations which seem to us in our ignorance to arise spontaneously. . . . I am convinced that Natural Selection has been the most important but not exclusive means of modification".

Prof. Cameron said that while Wallace gave a stimulus to Darwin to publish "The Origin of Species" in 1859, much of its immediate popularity was due to Herbert Spencer and Thomas Huxley. The theory of natural selection stated a fact and did not attempt to explain how the variation arose—merely how it was used. The kernel of the theory lay in heredity, and Mendel, almost simultaneously with the Wallace–Darwin papers a century ago, was laying the foundations of genetics to explain how interspecific variation was inherited. However, much still remained to be discovered, particularly the part played by the cytoplasm of the germ cells in producing major fundamental changes. The year 1958 marks not only the centenary of the Wallace–Darwin publication and the bicentenary of the tenth edition of the "Systema Naturæ" of Linneus, but also the century of the publication of the first description of Neanderthal man which directed attention to the fact that the evolution of man himself is the most important aspect of the theory.

Civilization represents the modern evolution of man and civilization has to grow and change, or decay and die. Growth and change do not always mean progress; in fact, the history of life on Earth shows that more often they lead to extinction. Man is the first and only animal, however, that has some control over his environment. Used wisely, that control can lead to progress.

"The constitution of the heavenly bodies and the structures of the atom," said Sir Oliver Lodge, "are in a sense elementary compared with the problems which confront those who would ascertain and disentangle even the material aspect presented by living things."

The following were elected to office in the Royal Society of Canada for the year 1958–59: *President*, M. Pierre Daviault; *Vice-President*, Dr. H. G. Thode; *Honorary Secretary*, Col. C. P. Stacey; *Associate Honorary Secretary*, Dr. Guy Sylvestre; *Honorary Treasurer*, Dr. N. E. Gibbons; *Honorary Editor*, Dr. G. W. Brown; *Honorary Librarian*, Dr. W. Kaye Lamb; *Editor of 'Studia Varia' for* 1959, Dr. T. W. M. Cameron; *President of Section* 3 (*Mathematical, Chemical and Physical Sciences*), Prof. G. M. Shrum; *President of Section* 4 (*Geological and Allied Sciences*), Dr. L. S. Russell; *President of Section* 5 (*Biological Sciences*), Dr. N. H. Grace.

FODDER PLANTS

A SYMPOSIUM on fodder plants, organized by the Institute of Plant Breeding of the Polish Academy of Sciences, was held at Poznań during June 25–27. It was attended by delegates from the U.S.S.R., the United States, Sweden, Germany, Hungary, Czechoslovakia and the British Commonwealth, who later had the opportunity of inspecting the experimental fields at the research stations of Baborówko and Przebedowo, near Poznań, and a number of other experimental stations farther afield. One of the most striking features of the symposium was that, although several of the contributions dealt with clovers, lucerne and other fodder plants, the great majority were devoted to lupins. Many areas of Poland have light sandy soils where lupins are among the few leguminous species that can be grown successfully. Mineral fertilizers seem to be in rather short supply, so that lupins are encouraged for the sake of their beneficial effects on soil fertility. Some are used as green manures. The greatest attention is, however, focused on the so-called sweet lupins which, owing to their low content of bitter alkaloids, can be used as fodder for livestock. The sweet lupins were first produced in Germany, and during the war years breeding work was carried out with them at Puławy in Poland. From this material hundreds of promising selections have now been produced and were demonstrated in the experimental fields. The most successful are selections of *Lupinus luteus*, which are more reliable in yield, but promising sweet selections of *L. albus* and *L. angustifolius* were also shown. The selections were distinguished by greater vigour and yield of green matter, earlier maturity, freedom from pod shedding, greater palatability, smaller seeds and other features.

By a group of investigators working at various research stations in Poland an intensive study has been made of the chemical structure of the lupin alkaloids, and many of the Polish contributions to the symposium dealt with these studies, largely based on analysis by paper chromatography. Several alkaloids not hitherto identified have been found, one of which has been named angustifolin, having been detected first in *Lupinus angustifolius*. On the basis of the structure of their alkaloids E. Nowacki (Poznań) has classified the genera of the family Genisteae, and the conclusions correspond with many arrived at on purely morphological features. Thus, *Laburnum* never contains spartein, its alkaloids, consisting of cytisin, methylcytisin and laburnin, whereas many *Cytisus* species contain spartein but no laburnin. The separation of the two genera is thus justified. *Sarothamnus* contains no cytisin and should be excluded from the genus *Cytisus*. In the same way the relationships between the species within the genus *Lupinus* have been assessed, and the grouping arrived at is borne out by considerations of the composition of the anthocyanins, flavones, proteins and fats and corresponds to the differences in chromosome number where these exist. A triple hybrid of (*L. ornatus* × *L. mutabilis*) × *L. douglasi* was described, some of the segregates being distinguished by high yield and earliness.

Papers presented by delegates from abroad included a review of the use of polyploidy in plant breeding in Sweden by A. Hagberg (Svalöf), who referred to three tetraploid clovers, one of rye and one of swede turnip produced at Svalöf; Ulva red clover exceeds the diploid by 11 per cent in yield, and Sirius swede exceeds the diploid by 16 per cent while having a dry-matter content of 12 per cent.

N. A. Majsurjan (Timirjazev Academy of Agriculture, Moscow) spoke of experience with sweet lupins in the Soviet Union. *Lupinus angustifolius* and the sweet forms of *L. albus* and *L. luteus* have large seeds, and efforts are being made to produce forms with small seeds. Sweet forms of *L. polyphyllus* are of interest, particularly on account of their earliness. From a cross of *L. angustifolius* × *L. linifolius* a promising form has been selected which combines the small seeds of the latter species with a plant type similar to *L. angustifolius*, together with earliness and low alkaloid content. Evidence was presented in support of the view that the species *L. mutabilis*, which crosses easily with the small-seeded American species such as *L. ornatus*, is itself a hybrid.

H.-J. Troll (Müncheberg) spoke of experiments on producing sweet forms of *L. luteus* and *L. angustifolius* which ripen uniformly and do not shed their seeds. Some useful mutants have been obtained by irradiation with X-rays, and latterly also with cobalt-60. J. Hackbarth (Max Planck Institut, Scharnhorst) spoke of mutants characterized by vigorous growth and others with a thermoneutral developmental reaction, suitable for growing in northern latitudes or for late sowing. W. Plarre (Hadmersleben) referred to experiments in which such thermoneutral types could be detected by vernalization and described a promising new hybrid produced by this means which is being released for cultivation in Eastern Germany. Several speakers referred to impressions that the sweet strains, especially those free from shedding, are inferior in yield, but evidence was given by Prof. Hackbarth and others to show that this is not necessarily so.

Contributions dealing with topics other than lupins included an account by N. Clark (Agricultural Experiment Station, Madison, Wisconsin) of the co-operative research on forage production leading, after twenty-five years of work, to the production of the first synthetic lucerne variety, Vernal. A detailed description was given by E. Åkerberg (Svalöf) of the development of the seed-production industry in Sweden, as a result of which Sweden now produces most of her own seed of the main species of forage plants. Among the achievements of plant breeding, special mention was made of the red clovers resistant to *Sclerotinia* and eelworm, the winter-hardy lucernes, the persistent and high-yielding white clovers, the polyploid clovers and strains with greater leafiness, better powers of a series of improved grass recovery and superior quality.

R. Focke (University of Rostock) mentioned some tetraploid red clovers that are 36 per cent better than diploid strains in fodder yield. They are, however, 20–40 per cent lower in fertility. Certain other speakers mentioned the same difficulty, though in certain cases a fairly satisfactory seed set had been obtained; thus a figure of 20 per cent was mentioned by H. Kress (Germany) for certain tetraploid red clovers, and up to 89 per cent in tetraploid white clover after selection for short corolla tube.

P. S. Hudson

SCIENTIFIC RESEARCH AND DEVELOPMENT IN EAST AFRICA

THE annual report of the East Africa High Commission for 1957*, in which a foreword by the chairman, Sir Evelyn Baring, records the tenth anniversary of the establishment of the High Commission, notes also the concentration of its eight departments in new headquarters in Upper Hill Road, overlooking the city of Nairobi. Almost half the report deals with the research and scientific services. The East African Agriculture and Forestry Research Organization records steady progress, and stress is laid on the value of the work on the full utilization of the inadequate or unreliable rainfall and on the chemistry of soil fertility. A statistical study of published data on the digestibility of the protein fraction of fodders indicated that all ruminants have the same ability to digest the protein in fodders, and that its digestibility in normal fodder depends solely on the protein level in the ration and not on its sources. The East African Veterinary Research Organization records further significant advances in the growth in cell culture of various types of rinderpest, Rift Valley fever and sheep pox, and the agar double diffusion precipitation test has been applied in the diagnosis of pleuropneumonia, while a co-operative project with visiting scientists from the United States is concentrating on African swine fever in the first instance.

The East African Fishery Research Organization has made extensive studies on the food of commercially important species, but its hydrological observations, which require extension, have been handicapped for lack of a vessel which can be used for prolonged journeys across Lake Victoria. The East African Marine Fisheries Research Organization has been provided with a new research ship, and the Organization has been able, in consequence, to extend its programme to include tuna long-line fishing on a greater scale. Under the East African Trypanosomiasis Research Organization different methods of collecting *G. pallipedes* have been studied in south-east Uganda as part of a fundamental study of the density of flies and their infection-rates. Work on trypanosome immobilization and complement-fixation tests continued, and methods have been developed for deep-freezing *T. brucei*, *T. rhodesiense* and *T. congolense* for up to seven months with solid carbon dioxide. Work on the trypanosomes in the fly has shown that the infection does not reduce the life of the fly. Physiological studies on tsetse flies are also reported.

Much of the work of the East African Institute of Malaria and Vector-borne Diseases is advisory; but its research activities have included studies of the life-cycle of anopheles, an experiment on the control of malaria in the Parc–Tavetz area, and bilharzia studies. The East African Virus Research Institute was concerned mainly with the natural history of the insect-borne virus diseases in East and Central Africa, but clinical work has now been started. The East African Institute for Medical Research continued its work on the absorption of foodstuffs, and the pilot scheme for eradicating filariasis on Ukara Island. The main work of the East African Leprosy Research Centre during the year was the therapeutic trial of diphenylthiourea started in 1956. The Lake Victoria Fisheries Board reports evidence that the species *Tilapia zillii* may help to offset the annual dearth of fish in the off-season of July. The East African Industrial Research Organization continued to investigate the artificial drying of Arabic coffee and is now providing an advisory service in fuel technology, while its work on the development of a sound technique for producing vitreous white ware pottery is emphasized. Expansion of the East African Metrological Department is planned and promising results were obtained in work on the reduction of evaporation of water from reservoirs with a film of cetyl alcohol.

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* Annual Report of the East Africa High Commission for 1957. Pp. x+85. (London: H.M. Stationery Office, 1958.) 7s. 6d. net.

The Desert Locust Survey maintained close co-operation with the Anti-Locust Research Centre and extra officers were recruited to deal with the re-invasion of the Somali Peninsula. Promising results were obtained in initial field aerial spraying tests with diazinon, and aerodel (11 per cent gamma-BHC) proved ideally suited for spraying locusts even in bad weather over difficult terrain. By the time the locusts started to breed in October 1957 the Survey had concentrated 30 officers and 125 vehicles in the Somaliland Protectorate and eastern Ethiopia and provided 65 vehicles in Somali with adequate supplies of bait and insecticides. Concern is expressed at the almost continuous nature of the threat since the War, but reference is also made to the development of international co-operation under the Food and Agriculture Organization of the United Nations and elsewhere.

SOIL ZOOLOGY

A COLLOQUIUM on "Research Methods in Soil Zoology", organized by the Soil Zoology Committee of the International Society of Soil Science, was held at Rothamsted Experimental Station during July 10–14, by permission of the director (Sir William Ogg) and the director of the Department of Entomology (Dr. K. Mellanby) and with financial assistance from Unesco and the Shell Petroleum Co., Ltd.

Although the titles of the 95 papers give an impression of great diversity, it is possible to distinguish certain themes which emerged from the papers and from the discussions and which are worth reporting to a wider public. This is so largely because the papers, grouped into five sections, were made available to members beforehand and (with a few exceptions) were not read at the conference; instead, the section recorders provided reviews of the papers, and these were then followed by really useful discussions, during which a reasonable amount of time was available for consideration of the most worthwhile topics.

Perhaps the most constantly recurrent theme was one which belongs most appropriately to Rothamsted, namely, the nature of the relationship between the biologist and the mathematician; this was introduced in the first section on "Methods of Sampling and Analysis". As J. G. Skellam pointed out, the relationships between the structures of the two subjects are indirect, and it is not always appreciated that it is the biologist and not the mathematician who must provide the working hypotheses that are to be tested by the application, for example, of statistical methods to his data. If the biologist simply provides a mass of undigested figures the mathematician is scarcely to be blamed if he erects his system of tests on a mathematically convenient but biologically unrealistic set of hypotheses. This theme was amply illustrated by speakers on such diverse topics as the spatial distribution of soil fauna, the analysis of species composition of communities and the measurement of efficiency of extraction methods.

A variant of this theme, on which the views of speakers proved irreconcilable, was the roles of experiment and statistical analysis in biological science. Whereas Dr. K. Mellanby and Prof. Kühnelt (Vienna) were advocates of the elegant laboratory experiment resulting in the production of few, but reliable, data and the support of field work wherever possible by laboratory experiment, Dr. J. E. Satchell (Merlewood) and others were strongly in favour of the use of mathematical analysis on selected field data, and Prof. M. Ghilarov (Moscow) and Prof. Franz (Vienna) were of the opinion that such methods are usually inappropriate owing to imperfect sampling methods and patchy distribution of soil organisms. Although there must obviously be room for great differences in approach to so wide a field, it was evident that the use of statistics as an analytical tool is still rather limited outside the English- and French-speaking countries and that the need for the kind of work that we associate with the name of Rothamsted is still great.

A most useful contribution to this liaison work was the first paper by M. J. R. Healy, whose survey of basic statistical techniques concluded with sections on non-random distributions and the use of transformations in variance analysis. Prof. H. R. Debauche (Louvain) as recorder of this section reviewed a wide range of topics in which mathematical techniques are appropriate to ecological studies, including, especially, the analysis of production and energy flow and the delimitation of communities. J. G. Skellam introduced a mathematical analysis of the use of extraction methods for population estimation with emphasis on the effect of extraction-rate and population heterogeneity on accuracy. Also from the Nature Conservancy D. D. Mountford introduced a new method for classifying species records into associated groups; this method was devised for the analysis of records obtained by J. E. Satchell covering between 50 and 100 species at each of ten sites, and is noteworthy, first, because an estimate of statistical significance is provided, and secondly, because this was the first occasion at the Colloquium on which the use of an electronic computer was reported, the distribution data for the species having been fed to the machine at Rothamsted on punch cards. Evidently this is but the beginning of a further field of application for these machines, for the next paper, by Dr. R. E. Blackith (Imperial College of Science and Technology), acknowledged their value in a discussion of the fields of application of multivariate analysis. Further contributions to this section were concerned with the study of distributions of aggregated populations along more or less familiar lines, Dr. R. D. Hughes (Wellesbourne) introducing a novel technique for estimating mean radius and frequency of patches of high density.

The second section, on "Extraction Methods", was reviewed by the recorder, Dr. P. W. Murphy, and was followed by demonstrations of apparatus and techniques. Some of the methods were already familiar, but new features introduced in the twenty-four papers or in the discussion included an extension of the use of suction methods for collecting ground surface arthropods, a machine for brushing microscopic species from leaves, the use of marking techniques both for population estimation and for assessment of the accuracy of extraction methods, the improvement of the extraction efficiency of Tullgren funnel methods by the control of humidity and the use of solar heat for funnels in large-scale faunal survey work in the U.S.S.R. Reports of comparative trials of different methods served to underline the variations in efficiency which occur when the same method is used on different animal groups, on different soil types and even in the hands of different operators.

The third section, on "Systematics and the Ecologist", was summarized by Dr. H. Gisin (president of the Committee), who was especially concerned with the relationships between the ecologist and the taxonomist when co-operating in the study of the more 'difficult' groups such as the mites and the Collembola. The taxonomist has the right to receive material in good condition, to be spared preliminary sorting and to make decisions about publication on taxonomic matters, in exchange for which the ecologist can expect rapid determination of selected material and the provision of keys at least to generic level. When determinations to species are required, a fruitful field of co-operation is provided because large ecological differences may accompany only small variations in morphology. There were differences of opinion about the value of reference collections, at least when these are uncritically used, and about the extent to which keys should be carried to the level of species, and should be limited to single countries or natural faunistic regions. Prof. Franz announced a scheme for the uniform publication of a series of keys to the European soil fauna under his editorship and published in Berlin, and Dr. G. O. Evans (British Museum, Natural History) described another scheme for a European key to genera of mites in collaboration with Dr. J. Balogh (Budapest) and Dr. K. Strenzke (Wilhelmshaven). A number of taxonomists present made pleas for correct mounting and preservation methods (not all of which were compatible) and described suitable techniques.

The fourth section, on "Soil Zoology and Pedology", was introduced by Prof. H. Franz (Vienna), who insisted on the need for close liaison between the two subjects. The influence of the past history of a soil on its present fauna and characteristics and the nature of the distinction between the aquatic and aerial components of the soil fauna were discussed. The papers in this section included two methods for studying the nature and rate of decomposition of the latter.

The fifth section, on "Laboratory Techniques", was ably reviewed by J. d'Aguilar (Versailles) and included twenty-nine papers on three main fields, namely: (1) the study of soil by sectioning, microscopical and photographic techniques; (2) the use of numerous special culture methods for different groups of soil animals; and (3) methods for studying metabolism of soil animals by means of radioisotopes and of a special micro-respirometer. Further details of techniques were provided in the discussion together with some sobering examples of ways in which unforeseen factors can cause faulty experimental results; in this way the complementary roles of laboratory and field work were vividly illustrated—at least to those not too far committed to one or other school.

The value of the colloquium was much enhanced by the efficient organization of the secretaries, Dr. P. W. Murphy (Rothamsted) and J. d'Aguilar (Versailles), and owed much to the wise and sympathetic chairmanship of Dr. Mellanby and his colleagues. The discussions throughout were recorded, and translation was ably supplied between English and German. The proceedings, including the discussions, are to be published this year by Messrs. Butterworths in two volumes, the first covering Sections 1–4, and the second containing the papers in Section 5 which are thought likely to have a wider appeal.

A. MACFADYEN

BRITISH COAL UTILIZATION RESEARCH ASSOCIATION

THE annual report* of the British Coal Utilization Research Association for 1957 includes a brief review of the Association's research work. The major objectives during the year were to help in bridging the gap between suitable coal supplies and energy requirements and assisting the implementation of the Clean Air Act. The development of a small-pipe system for central heating was substantially completed, as was work on the formulation of procedures and the design of equipment for measuring the emission of grit and dust; an automatic particle counter and sizer developed by the Association is now in commercial production. Tests at Leatherhead on the stationary locomotive boiler were also completed and further experimental work with the model furnace-tube plant has reduced the unaccounted heat loss to about 2–3 per cent Increased attention is now being given to automatic control of firing appliances and, with the increasing use of small coal in such equipment, to the study of grit and dust catchers. An improved method was devised for controlling the air distribution through the fuel beds of chain grate stokers for boilers of the shell type, and methods of alleviating the rapid corrosion at the cold end of a boiler, particularly of air heater surfaces, have also been investigated.

Laboratory studies continued on the mode of release of chlorine, alkalis and sulphur from coal up to 1,500° under shock heating conditions, and further tests have shown that the potential tar yield of the coal as defined by the Gray King Assay provides a good basis for comparing coals for tar content. Problems associated with the production of fuel or synthetic gas in gasifiers operating at high pressures and temperatures, at which the ash is in the form of liquid slag, were also investigated with the view of utilizing small low-rank coal.

Basic research included investigations into the chemical basis of the plastic softening of coals, with the view of better control of coking properties; studies of the fundamental reactivity of graphite towards oxidizing gases in relation to porous structure; and on the solvent extraction of a medium-rank coal with tar oils, using ultrasonic extraction equipment, to produce a smokeless fuel with coal extract as a by-product. A further step was taken towards the establishment of the absolute significance of measurements of surface areas of coals and carbonized coals by the heat of wetting method. A list of reports and published papers is appended.

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* British Coal Utilization Research Association. Annual Report 1957. Pp. ii+62+4 plates. (Leatherhead: British Coal Utilization Research Association, 1958.) 10s.

JUBILEE OF ESKDALEMUIR OBSERVATORY

ESKDALEMUIR Observatory, the geomagnetic and meteorological observatory in a remote situation in north-east Dumfriesshire, was founded on May 11, 1908. It was established because the westward extension of electric tramways from London rendered the magnetic observations at Kew Observatory insufficiently exact for many purposes. Compensation of £10,000 was paid by the tramway company to the National Physical Laboratory, under which the geomagnetic work at Kew Observatory then came, and this money was used to build Eskdalemuir Observatory. The site is reputed to have been chosen by placing a coin on a map so as not to intersect any town or railways within 10 miles. Eskdalemuir came with Kew under the control of the Meteorological Office in 1910.

The history of geophysical work at Eskdalemuir and plans for the future are given by the present superintendent, Mr. M. J. Blackwell, in the May 1958 number of the *Meteorological Magazine*.

The Observatory has been throughout a first-order geomagnetic and meteorological observatory. Until 1925, in which year the seismographs were transferred to Kew, it was also a seismological observatory.

Three sets of magnetic instruments, each set recording horizontal force, declination and vertical force, are now in use. The three sets are of different sensitivity and traversing rate and serve different purposes. The magnetographs are in a non-magnetic underground house, the temperature of which is thermostatically controlled. Absolute observations of the magnetic elements are also made, of course. It is interesting to note that the declination of 18° W. in 1908 has now decreased to less than 11° W. The records of the magnetographs are analysed at the Observatory, work which continually becomes more complex.

In meteorology and atmospheric physics, extensive work is done in climatology, solar radiation, atmospheric ozone and atmospheric electricity, to mention but a few of the main activities. The apparatus for measuring precipitation includes a variety of standard and experimental rain and snow gauges. Special observations undertaken during the present International Geophysical Year are chemical sampling of air and rain-water, measurements of evaporation and investigation of the vertical distribution of ozone.

The situation of the Observatory has meant that accommodation has to be provided for all the staff, with associated domestic workers, who form a small community—in early years a very isolated one.

Mr. J. Crichton, a former superintendent of Eskdalemuir, wrote in the *Meteorological Magazine* in 1950 : "So far no encroachment by artificial (magnetic) disturbance has taken place". In expressing good wishes to the Observatory for its next fifty years, we can hope that the happy state of absence of artificial disturbance will continue.

FORESTRY POLICY IN BRITAIN

THE Minister of Agriculture, Fisheries and Food, Mr. J. Hare, in a statement on forestry policy in the House of Commons on July 24, said that the Government had reviewed the position and decided to fix the planting programmes of the Forestry Commission for periods of ten years at a time. For 1959–63 the programme would be about 300,000 acres, and for 1964–68 it would be reduced to about 235,000, when the Commission's existing plantations began to come into full production. The size of subsequent programmes would be reviewed in five years time in the light of the national needs, and in deciding when planting should take place, special attention would be paid to the upland areas, particularly in Scotland and Wales, where expansion of forestry would provide needed diversification of employment and important social benefits.

The Government proposed to continue its support to private woodland owners, particularly through the dedication scheme, but the present maintenance grant of 5*s*. 6*d*. per acre would be replaced by a management grant of 18*s*. per acre on the first 100 acres, 12*s*. on the next 100 and 7*s*. per acre on the rest. The planting grant would be continued, but for approved woodlands would be raised from one half to the full rate per acre. These increased grants are contingent on the formation of an effective woodland owners' association, as recommended by the Watson Committee. The grants for thinning and poplar planting would be terminated, and, in reviewing in future years the level of grants, trends in receipts for private woodlands as a whole as well as trends in costs would be considered. Eventually—in twenty to thirty years time—the level of assistance needed by way of planting and management grants should become nominal. The system of felling licences would be continued ; a statutory instrument would eliminate the need for a licence for fellings in dedicated woodlands, and in general licences would be freely granted for other fellings, subject to the existing arrangements for consultation with planning authorities. Normally, licences would be conditional upon restocking. In reply to questions, Mr. Hare said that the Forestry Commission would consult the woodland owners' organizations in assessing trends in receipts and costs, that his Department was working in the closest possible co-operation with the Secretary of State for Scotland and the Forestry Commission and that there would be no interference with the assistance now given by the Commission to farmers who sought to replant scrub land and land covered with bushes and trees.

LEAF AREA AND PASTURE GROWTH

AGRICULTURISTS are ultimately concerned with yield per unit area of land, and it is the aim of plant physiologists interested in agricultural problems to attempt to analyse the causes of variation in yield. In a recent review entitled "The Significance of Leaf Area in Pasture Growth", by C. M. Donald and J. N. Black of the Waite Agricultural Research Institute, Australia (*Herbage Abstracts*, 28 ; 1958), it is pointed out that of the chief physical factors limiting yield, water and nutrients have received more attention than light, particularly in pasture studies. Under field conditions the amount of light falling on a pasture is not controlled by man, nor is it subject in any particular locality to the same degree of annual fluctuation as is rainfall. When light is the only limiting factor the ultimate capacity of a species to produce dry matter depends on the degree to which a community of such plants can exploit the light falling on it. This will depend on the habit of the plant. The yield, therefore, will depend to a great extent on the area of photosynthetic tissue which is able to intercept light energy, that is, the leaf area. Consequently, the important factor is the relationships of leaf surface to soil surface, and this was first put on a quantitative basis by D. J. Watson in his concept of 'leaf area index', which is defined as the leaf area per unit area of land. This index has the virtue of being a measure of the whole crop rather than of individual plants.

Watson postulated that the greatest dry-matter production would occur when the maximum leaf area coincided with seasonal conditions most favourable for photosynthesis. The development of a leaf system capable of intercepting a high proportion of the incoming light energy is of great importance in the growth of field crops ; at values of the index below this level, maximum growth cannot occur. On the other hand, at higher values mutual shading of leaves may result in a reduction in growth-rate of the crop.

The limited number of determinations of the leaf area index of pastures suggests that these values may considerably exceed that of crops, and it is suggested that there may be several reasons for this. First of all, the types of plants which have been selected by man to sow pastures for his animals are those with heavy leaf production. A second major aspect affecting the index is the greater number of plants per unit area in pastures compared with crops.

The authors emphasize that the application of the concept of leaf area index to problems of pasture growth is of great potential value. They stress that provided other conditions are optimum light is the only limiting factor determining productivity of a pasture and that efforts to increase production beyond the high levels already recorded in some environments may be in vain unless this limiting factor is fully appreciated. With these concepts clearly in mind the object in pasture management will be to pass as rapidly as possible to the optimum leaf area index for pasture growth and then to hold the pasture at this level. Any operations which delay this process, such as early grazing when the index is low, will substantially delay attainment of the optimum and may have an effect on subsequent production quite disproportionate to the amount removed. Other aspects of pasture production capable of analysis in terms of leaf area index are pointed out.

LABORATORIES IN GRAMMAR SCHOOLS

THE inadequate provisions for science teaching in grammar schools have been brought out only too clearly in the answers to a questionnaire which was sent to some 2,000 schools about a year ago*. The 472 schools from which data were considered are widely distributed over the whole of England and Wales, with a slight bias towards London and the surrounding counties.

These schools contained about 25,000 pupils, of whom 90·9 per cent took some science. This is a reassuringly high proportion which does not vary much between the extremes of 86·5 per cent in independent boys' schools and 93·9 per cent in the small grammar schools. How much science was studied was not indicated, and, for many pupils, the time devoted to science may be very small, perhaps only one or two periods a week.

Almost all pupils do some science in the first three years of their secondary courses. In the fourth year the percentage figures drop a little, and in the fifth (O-level) year, about 90 per cent of pupils are taking science, although not all of these will offer science subjects in the O-level examination. The dropping of science in the fourth and fifth years may occur because subject specialization is already starting, or it may be because sufficient teachers or laboratories or both are not available.

In the sixth form there is a considerable fall in the percentage of pupils taking some science. This is particularly marked in the girls' schools, being only 47 per cent in the two categories of grammar schools having 300–399 pupils and 400–549 pupils, 44 per cent in the 500–699 category, and 39 per cent in the larger schools. The corresponding figures for boys' schools are 66, 60, 61 and 65 per cent.

Expressed as a percentage of total sixth-form numbers, the figures for girls' schools are about half of those for boys' schools. Since the sixth forms in girls' schools are smaller than in boys' schools, the number of girls specializing in science is less than half the number of boys.

These results support the view that girls' schools could be an important source of the increased number of scientists required in industry, in Government departments, for teaching and for many other purposes.

One question required each school to state its total number of laboratories and other rooms having a special connexion with the teaching of science. Using the standards framed by other responsible bodies, namely, the Ministry of Education and the Committee of the Industrial Fund for the Advancement of Scientific Education in Schools, the figures reveal the inadequacy of existing provisions.

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* *School Science Review*, 39, No. 139 ; June 1958.

More than half of the schools which appear to be adequately provided with laboratories by Ministry of Education standards are girls' and mixed schools which, if considered by the higher standards the Ministry adopts for boys' schools, would not be regarded as adequately provided.

An attempt was also made to discuss the existing provision for laboratory assistance. Out of 362 maintained grammar schools answering the questionnaire, 92 (25 per cent) have no laboratory assistance at all. 31 (8·6 per cent) have only part-time help, and 78 (22 per cent) have only one junior assistant. 85 per cent are not adequately provided with laboratory assistance.

The amount spent each year on science in grammar schools is revealing. 144 out of 337 maintained grammar schools, that is, 43 per cent, had less than 8*s*. per year per pupil taking science. At one extreme an independent boys' school has £3 10*s*. per year for each pupil taking science, while one direct-grant boys' school has £2, and one independent girls' school has £1 15*s*. 9*d*. The highest figure shown by a maintained boys' school is £1 8*s*. 8*d*., and for girls' £1 5*s*. 10*d*. At the other extreme, one boys' grammar school has only between 1*s*. 3*d* and 3*s*. 6*d*. annually for each pupil taking science. Financially, as in other respects, girls' schools are, in general, considerably worse off than boys' schools. It appears that the schools with less than 10*s*. yearly for each pupil taking science (that is, about half of the grammar schools) are being subjected to conditions which are frustrating and inimical to the work they are called upon to do.

Schools were invited to make general comments concerning difficulties encountered in science departments. 256 schools gave seventy different reasons for the difficulties they faced. Among reasons given which received considerable support were: (*a*) accommodation generally cramped and crowded (79); (*b*) sharing accommodation or using another school's science laboratories (13); (*c*) laboratories too small (14); (*d*) no advanced laboratories (16); (*e*) laboratories widely dispersed—in several cases by a mile or more (19); (*f*) no preparation rooms (10); (*g*) out-of-date and/or ill-designed laboratories (14); (*h*) laboratories used as form rooms (21); (*i*) much science teaching in class-rooms (16); (*j*) serious shortage of storage space (22); (*k*) inadequate finance, lack of capital grant, etc. (33); (*l*) shortage of staff (28); (*m*) lack of suitable qualified staff (28); (*n*) too many young and inexperienced staff (14); (*o*) staffing ration not generous enough, time-table too heavy, etc. (17); (*p*) classes far too large (24); (*q*) no laboratory assistants (22); (*r*) inadequate or poor quality laboratory assistants (48).

MEDICAL RESEARCH IN INDIA

THE Technical Report of the Scientific Advisory Board, published annually by the Indian Council of Medical Research (pp. xii+290. New Delhi: Indian Council of Medical Research, 1957. Rs. 1), has primarily included detailed reports of work done under all the research schemes financed by the Council during the year. The report for 1956, as a measure of economy, contains only short abstracts of work done under research schemes financed during 1955–56. Of these, 52 relate to chemical research, 5 each to cholera and leprosy, 9 to malaria and other arthropod-borne diseases, 10 to tuberculosis, 3 to venereal diseases, 4 each to environmental hygiene and sanitation and to industrial health, 16 each to maternal and child health, to nutrition, to physiology and pharmacology, 1 to mental health, and 7 to virus diseases. Besides details of the Scientific Advisory Board and its Advisory Committees and Sub-committees, the report includes lists of papers published by workers of the Indian Council of Medical Research in 1956 and of those dealing with work done under the auspices of the Council and published in 1956.

From this array of papers it is almost impossible to select any for particular mention, but as of more general scientific interest reference may be made to the electron microscopic investigations on micro-organisms under Prof. K. N. Das Gupta at the Institute of Nuclear Physics, Calcutta; to the leprosy research work under Dr. N. Mukerjee at the School of Tropical Medicine, Calcutta; the laboratory and field investigations at the Malaria Institute of India, Delhi, on resistance in houseflies and mosquitoes to chlorinated hydrocarbon insecticides and the comparative efficiency of different insecticides against mosquitoes; on the control of *W. malayi* filariasis in Travancore–Cochin with diethylcarbamazine; the studies in vitamins, proteins and fats at the Nutrition Research Laboratories, Coonoor; and on the biosynthesis of ascorbic acid by the Nutrition Research Unit at the University College of Science and Technology, Calcutta.

The Indian Council of Medical Research has also issued a review of the progress made in the research projects it sponsors covering the whole of the period 1950–57 (pp. v+169. New Delhi: Indian Council of Medical Research, 1957). The survey is intended to convey some idea of the philosophy and approach of the Indian Council of Medical Research to the development of medical research in India, the contribution being made towards public health and the direction in which it is moving. Among the features stressed in the introductory review are the measures taken against malaria, filariasis, leprosy, plague, tuberculosis, trachoma and preventable blindness; the new outlook on cholera and venereal disease and malnutrition and virus disease. The survey gives a concise and readable account of the organization of medical research in India, both in diverse fields of research, between different institutions and of the balance between fundamental and applied research. Besides this section, which displays a vision, determination and resource on which the Council and Government of India are to be highly congratulated, there is a section on progress in selected fields, while a further section on the year ahead, as well as the concluding section, show that the Council is fully alive to the factors upon which effective scientific work depends and is seeking to provide the scientist, not simply with the institutions and equipment, but also with the conditions of service in which he can give of his best.

PARTITION OF PROTEINS IN LIQUID POLYMER–POLYMER TWO-PHASE SYSTEMS

By Dr. PER-ÅKE ALBERTSSON

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THE behaviour of proteins in liquid two-phase systems has been of increasing interest because partition chromatography and counter-current extraction have been shown to be useful tools for the fractionation of protein mixtures, thus complementing adsorption chromatography and zone electrophoresis[1,2].

Suitable two-phase systems for proteins are difficult to construct, mainly because (*a*) most proteins are easily denatured or precipitated by the organic solvents usually used for preparing phase systems, and (*b*) proteins are macromolecules and have, therefore, a general tendency to concentrate only in one phase, that is, one obtains either very high or very low partition coefficients. When, as sometimes happens, two proteins concentrate in different phases this is, of course, an advantage since it leads to large separation factors. If, however, two proteins go to the same phase it is difficult to apply partition chromatography or counter-current extraction for their separation.

To overcome these difficulties, phase systems have been used which are made by mixing water, salt, and organic solvents soluble in water, like alcohol, glycol ethers, etc.[1–7], in such proportions that the composition is near the plait point. Such systems dissolve many proteins and give finite partition coefficients. Near the plait point the partition coefficient is, however, extremely sensitive to small changes in the composition of the phase system which, in turn, is sensitive to variations in the temperature. The composition and temperature must therefore be controlled very carefully.

This communication describes some results that have been obtained when proteins are distributed between two-phase systems composed of water and two high polymers soluble in water. Such systems have been used for the fractionation of cellular particles[8]. Ref. 8 also contains references to the theory and experiments on polymer–polymer phase separation in general. It is well known that when two different polymer solutions are mixed, phase separation occurs, even at low concentrations of the polymers. Of the two phases thus obtained, one contains almost all of one polymer and the other phase almost all of the other. Both phases, however, usually contain between 80 and 99 per cent of water, depending upon the type of polymer used and its mean molecular weight.

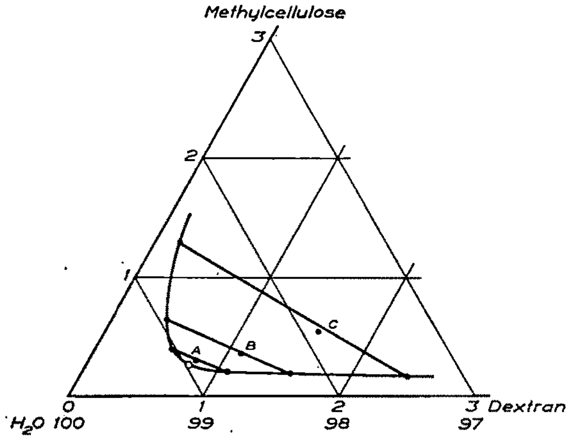

Fig. 1. Part of a phase diagram with tielines for the system dextran–methylcellulose–water at 20° C. ○, plait point. The compositions of *A*, *B* and *C* have been used for the determination of the partition coefficients of proteins (see Table 1). (Composition per cent w/w.)

Fig. 1 shows a typical triangular phase diagram of a polymer–polymer system, dextran, methylcellulose and water. (The dextran was obtained from AB Pharmacia, Uppsala: intrinsic viscosity, 0·68; weight average molecular weight, 1,800,000; number average molecular weight, 280,000. The methylcellulose, 'Methocel', was obtained from the Dow

Table 1. The Partition Coefficient of certain Proteins in the Two-phase System Dextran–Methylcellulose–Water at the following three total Compositions (w/w) (compare Fig. 1):
A, 0·80 per cent dextran, 0·30 per cent methylcellulose, 98·90 per cent buffer + protein; *B*, 1·10 per cent dextran, 0·36 per cent methylcellulose, 98·54 per cent buffer + protein; *C*, 1·58 per cent dextran, 0·54 per cent methylcellulose, 97·88 per cent buffer + protein
Protein content in the total system 0·1–0·2 per cent w/w

Protein	Mol. weight × 10^3 (ref. 10)	Partition coefficients			*p*H	Molar concentration of phosphate buffer	Kind of protein determination†
		System *C*	System *B*	System *A*			
Ribonuclease	13	0·96			6·8	0·01	*N*
Cytochrome *c*	16	0·95			6·0	0·01	E_{410}
Pepsin	36	1·4			4·6	0·01	*N*
Ovalbumin	44	0·82			6·0	0·01	*N*
Laccase (fungal)	*	0·8			6·0	0·01	*EA*
Hæmoglobin (man)	67	0·79	0·96	0·99	6·0	0·01	E_{420}
Serum albumin (man)	69	0·81			6·0	0·01	*N*
Enolase	68	0·76			6·0	0·01	*EA*
Caeruloplasmin	151	0·7			6·0	0·01	*EA*
Gammaglobulin (man)	156	0·6			6·0	0·1	*N*
Fumarase	204	0·65			7·0	0·01	*EA*
Catalase	250	0·75			6·0	0·01	E_{406}
C-Phycocyan	270	0·63			6·0	0·01	E_{620}
R-Phycoerythrin	290	0·68	0·85	0·95	6·0	0·01	E_{495}
Fibrinogen (man)	340	0·3			6·0	0·1	*N*
Hæmocyanin eighth (*Helix pomatia*)	1,000	0·25	0·5	0·8	8·5	0·01	*N*
Hæmocyanin whole (*Helix pomatia*)	9,000	< 0·1	—	0·5	6·0	0·01	*N*
Tobacco mosaic virus	40,000	—	—	0·06	6·0	0·01	*N*

* Molecular weight not determined. $S_{20} = 6·0$ (ref. 11). A molecular weight of 60,000 was assumed when plotting the data for laccase in Fig. 2.
† *N*, nitrogen determination according to Kjeldahl; *EA*, enzyme activity; *E*, extinction. Figures indicate wave-length in mμ.

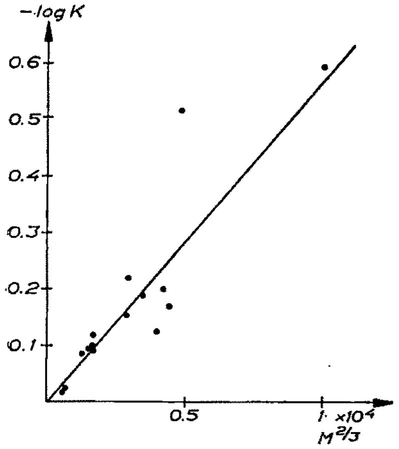

Fig. 2. Relation between partition coefficient (K) and the molecular weight (M) of the proteins in system G (compare Fig. 1 and Table 1)

Chemical Co.: 31·5 per cent methoxyl; viscosity, 4,149 centipoises; average molecular weight, ~150,000.) Other systems such as dextran–polyvinyl alcohol–water and dextran–polyethylene glycol–water have already been described[8]. As Fig. 1 shows, one phase (bottom) consists mainly of dextran and water, and the other (top) of methylcellulose and water, except very near the plait point.

Three compositions, represented by the points A, B, C on the phase diagram (Fig. 1), were selected for further study.

The partition coefficient of a number of proteins was determined in these systems in the following way. One gram of an aqueous protein solution previously dialysed against buffer (see Table 1 for concentrations) was added to 9 gm. of a mixture of dextran, methylcellulose and buffer in a separating funnel so that the desired composition as indicated in Table 1 was obtained. The mixture was allowed to equilibrate in a thermostat at 20° C. and was shaken by turning the funnel upside down about fifty times. The phases were then allowed to separate overnight. Portions of the top phase and the bottom phase were then collected, weighed and diluted appropriately for the determination of the protein content.

As indicated by the results in Table 1, all proteins, except pepsin, concentrate in the dextran-rich phase.

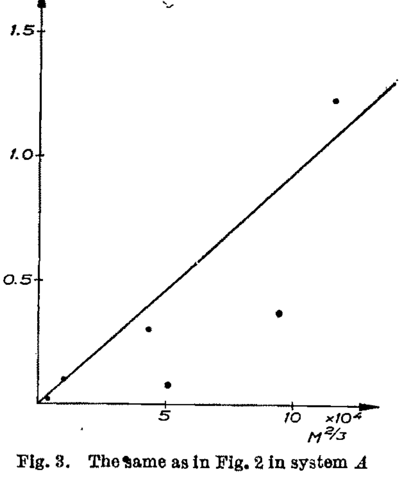

Fig. 3. The same as in Fig. 2 in system A

Even far from the plait point most of the proteins have measurable finite partition coefficients between 0·1 and 1. This differs considerably from the results obtained with low molecular weight phase systems[4–7].

There is a significant correlation between the partition coefficients and the molecular weights of the proteins (Table 1). The conditions were not exactly similar for all the proteins, so the partition coefficients cannot strictly be compared, but the general tendency is obvious. The pH and ionic strength also affect the partition coefficient, but not to the same extent as the molecular weight, provided the protein molecule is stable. If the protein molecules aggregate, or dissociate, due to changes in pH or ionic strength, these latter factors will, however, affect the partition coefficient considerably.

The results in Table 1 (see also Figs. 2 and 3) are compatible with the theory of the partition of macromolecules in two-phase systems originally worked out by Brönsted[9]. He derived the following relationship between partition coefficient (K) and the molecular weight (M) of 'isochemical' substances:

$$\log K = \frac{\lambda}{RT} \cdot M$$

where λ is a constant characteristic of the phase system and the type of substance. If the partitioned molecules are globular, like most proteins, M should be replaced[9] by $M^{2/3}$.

A closer comparison with theory will be postponed until more experimental results are available and a wider range of partition coefficients have been determined.

It seems that analysis of the partition in this phase system would be a simple way to obtain at least a rough estimate of the molecular weights of proteins. For example, the determination of the partition of enzymatic and hormonal activity and substances of low molecular weight in crude mixtures like cell homogenates could give information as to the size of the particles to which these activities and substances are attached.

The proteins seem to dissolve without denaturation. The enzymes retain at least 90 per cent of their activity. With hæmocyanin, however, precipitation was occasionally observed at low pH values.

The system dextran–methylcellulose–water is comparatively insensitive to changes in temperature. The time necessary for the two phases to separate is about 12, 6 and 1 hr. for the systems A, B and C, respectively. The top phase of system G is rather viscous, and small drops of the bottom phase remain in it for some time, but this introduces no serious error in the determination of partition coefficients between 0·1 and 1. In both systems, B and C, the two phases can be separated in a few minutes by centrifugation at low speed, for example, 2,000 g, without taking special precautions to control the temperature.

Table 2. PARTITION OF PROTEINS IN THE SYSTEM DEXTRAN–POLYETHYLENE GLYCOL–WATER WITH DIFFERENT FRACTIONS OF THE POLYMERS

The proteins are partitioned with finite partition coefficients but in favour of the phase indicated in the columns under the proteins. Compare ref. 8, Table 4. *PEG*, polyethylene glycol

Phase system. (Nos. indicate mol. wt. of polymers)	Hæmoglobin	Serum-albumin	Phycoerytrin	Phycocyan
Dextran 20,000–*PEG* 6,000–7,500	dextran	dextran	dextran	dextran
Dextran 1,800,000–*PEG* 6,000–7,500	,,	,,	*PEG*	*PEG*

Other polymer systems are also able to dissolve proteins. In the system dextran–polyethyleneglycol–water, the distribution of some proteins is highly dependent upon the molecular weight of the two polymers. Thus, the partition coefficient can be shifted from less than one to greater than one by replacing one of the polymers by another fraction of the same polymer with a different molecular weight (Table 2). This is analogous to the distribution of particles in similar phase systems as described earlier[8].

An obvious difficulty of this method of protein separation is that the phase system components cannot easily be removed by dialysis. However, this could possibly be overcome by zone electrophoresis or adsorption of the proteins, on an ion exchanger or calcium phosphate, for example.

Further work is in progress, and a detailed report will probably be published later.

I wish to express my thanks to Prof. A. Tiselius for stimulating interest and support. The work has been aided by grants from the State Council of Technical Research.

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FORMS OF PYRIDINE NUCLEOTIDES IN RAT-LIVER MITOCHONDRIA

By Dr. J. L. PURVIS

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IN connexion with studies to determine whether mitochondrial isocitric dehydrogenase is a linked nucleotide with di- or tri-phosphopyridine, it was necessary completely to deplete the mitochondria of their pyridine nucleotides. The depletion was followed by determining the amounts of oxidized and reduced di- and tri-phosphopyridine nucleotides by specific enzymic, fluorometric methods[1] applied to acid and alkali extracts of mitochondria after different times of incubation. Fig. 1 describes an experiment in which the mitochondria were incubated with 40 m*M* phosphate (Fig. 1 *A*) and with 1·9 m*M* adenosine diphosphate + 33 m*M* nicotinamide (Fig. 1 *B*). Fig. 1 *A* shows that the depletion of diphosphopyridine nucleotide consists of two phases: first, the conversion of reduced diphosphopyridine nucleotide to its oxidized form; and secondly, destruction of the oxidized diphosphopyridine nucleotide. The oxidation of reduced triphosphopyridine nucleotide occurred somewhat slower but in a similar manner. Nicotinamide inhibited the destruction of the oxidized nucleotides (Fig. 1 *B*).

Fig. 1 also shows that during incubation with 40 m*M* phosphate or 1·9 m*M* adenosine diphosphate the content of diphosphopyridine nucleotide reacting with yeast alcohol dehydrogenase increased to a value above the total of both oxidized and reduced nucleotides at zero time. The extra diphosphopyridine nucleotide must be derived from some precursor. Since the increase occurred after incubation with phosphate, adenosine diphosphate or 2,4-dinitrophenol but not with adenosine triphosphate, it is probably due to the breakdown of a compound containing diphosphopyridine nucleotide rather than to a synthesis of that nucleotide. Moreover, pyridine nucleotide synthesis is localized in the nucleus[2]. A similar increase in the total of oxidized and reduced triphosphopyridine nucleotides during the incubation indicates that the increased diphosphopyridine nucleotide does not result from a conversion of triphosphopyridine to diphosphopyridine nucleotide. The fact that the compound containing diphosphopyridine nucleotide yields this nucleotide on addition of phosphate, adenosine diphosphate or 2,4-dinitrophenol but not adenosine triphosphate strongly suggests that it is connected with oxidative phosphorylation. In fact, it has the properties expected of a diphosphopyridine nucleotide compound (DPN $\sim I$) which has been postulated as an energy-rich intermediate of oxidative phosphorylation[3,4]. The concentrations of phosphate, adenosine diphosphate or 2,4-dinitrophenol necessary to give a half-maximal appearance of diphosphopyridine nucleotide from its reduced form and the energy-rich intermediate were 3·5 m*M*, 185 μ*M* and 4·5 μ*M*, respectively. The half-maximal concentration of adenosine diphosphate in the presence of 2 m*M* phosphate was 70 μ*M*. These K_m values follow the same order as in oxidative phosphorylation.

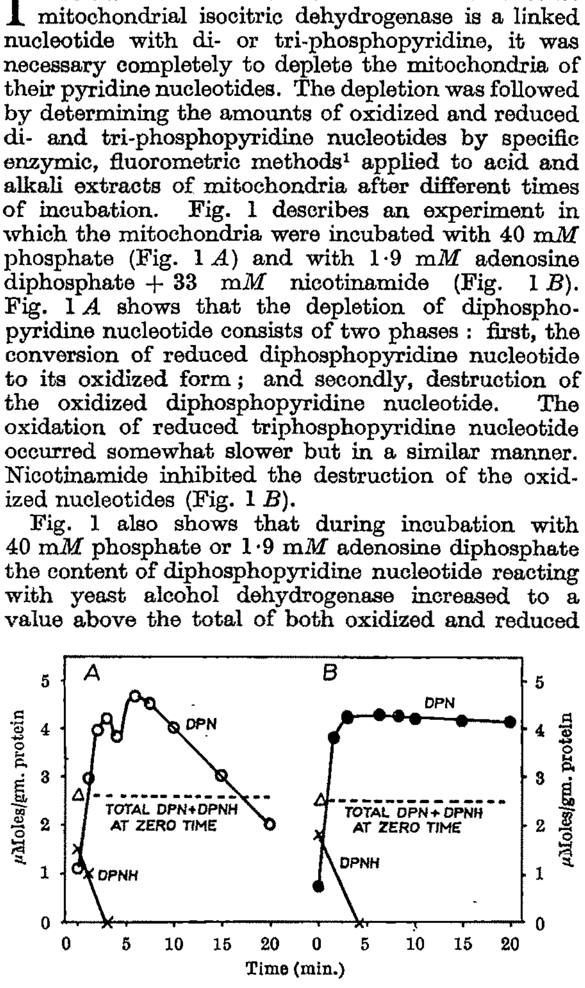

Fig. 1. The mitochondria were incubated at 30° C. with 40 m*M* phosphate (*A*) and with 1·9 m*M* adenosine diphosphate + 33 m*M* nicotinamide (*B*)

The amounts of the various forms of the pyridine nucleotides in mitochondria are given in Table 1. Recovery experiments with added reduced di- and tri-phosphopyridine nucleotides ranged from 90 to 110 per cent. Thus the increase in total pyridine nucleotide after incubation is not due to an under-estimation of reduced di- and tri-phosphopyridine nucleotides.

Eisenhardt and Schrachinger[5] have estimated the amount of high-energy compounds present in liver mitochondria, non-respiring owing to lack of phosphate acceptor, by the rapid increase in the concentration of adenosine triphosphate which occurs

Table 1. CONCENTRATIONS OF DIFFERENT FORMS OF PYRIDINE NUCLEOTIDES IN RAT-LIVER MITOCHONDRIA

The pyridine nucleotides were determined at zero time and after 7 min. at 30° in the presence of 40 m*M* potassium phosphate or 1·9 m*M* adenosine diphosphate. The values, expressed as µmoles/gm. protein, are the means from 13 experiments

	0 min.	7 min.
DPN	1·05	4·32
DPNH	1·6	0
DPN + DPNH	2·65	4·32
DPN $\sim I$	1·67	—
TPN	0·27	4·85
TPNH	2·1	0
TPN + TPNH	2·37	4·85
TPN $\sim I$	2·48	—

immediately after adding adenosine diphosphate. This value, 1·5 µmoles/gm. protein, is similar to our value for the diphosphopyridine nucleotide intermediate (1·67 µmoles/gm. protein).

Amytal (5-amino-5-ethylbarbituric acid), in a concentration of 1·8 m*M*, completely blocks oxidations linked with diphosphopyridine nucleotide in rat-liver mitochondria[6], acting between flavoprotein and diphosphopyridine nucleotide[7]. In the presence of 0·8 m*M* amytal, 33 m*M* nicotinamide and 1·9 m*M* adenosine diphosphate, the reduced diphosphopyridine nucleotide content of liver mitochondria decreased slowly, while the content of the oxidized form remained relatively constant. Under these conditions 75 per cent of the reduced diphosphopyridine nucleotide disappeared, presumably by conversion to the disphosphopyridine nucleotide intermediate. The diphosphopyridine nucleotide which disappeared could be recovered by dilution and addition of 2,4-dinitrophenol. A higher concentration of amytal (1·8 m*M*) completely inhibited any change in the concentrations of diphosphopyridine nucleotide or its reduced form.

Alterations in the disphosphopyridine nucleotide intermediate concentration can also be produced by the addition of substrate. The addition of β-hydroxybutyrate to liver mitochondria at 0° C., in the presence of 3·0 m*M* magnesium but in the absence of phosphate acceptor, caused the concentrations of both oxidized diphosphopyridine nucleotide and its reduced form to increase in 90 sec. The addition of α-ketoglutarate, succinate or glutamate, on the other hand, caused a sharp decrease in oxidized diphosphopyridine nucleotide without a corresponding increase in its reduced form, indicating an increase in the diphosphopyridine nucleotide intermediate. Thus this energy-rich intermediate breaks down in the presence of β-hydroxybutyrate and accumulates in the presence of α-ketoglutarate, succinate or glutamate in the absence of phosphate acceptor.

The interconversions of the various forms of diphosphopyridine nucleotide in rat-liver mitochondria may be explained by the formulation of respiratory-chain phosphorylation currently used in this laboratory[3,8]. Substituting reduced diphosphopyridine nucleotide for AH_2, flavoprotein (*fp*) for *B* in the general formulation we have:

$$(1)\quad \mathrm{DPNH} + fp + I \rightleftharpoons \mathrm{DPN} \sim I + fp\mathrm{H}_2$$

$$(2)\quad \mathrm{DPN} \sim I + X \rightleftharpoons X \sim I + \mathrm{DPN}$$

$$(3a)\quad X \sim I + \mathrm{P}_i \rightleftharpoons X \sim \mathrm{P} + I$$

$$(3b)\quad X \sim \mathrm{P} + \mathrm{ADP} \rightleftharpoons \mathrm{ATP} + X$$

$$(4)\quad X \sim I + \mathrm{H_2O} \xrightarrow{\mathrm{(DNP)}} X + I$$

(The following abbreviations are used: P_i, inorganic phosphate; ADP, adenosine diphosphate; ATP, adenosine triphosphate; DNP, 2,4-dinitrophenol; DPN, diphosphopyridine nucleotide.)

It can be seen from reactions (1) and (2) that both free *I* and *X* are needed to convert reduced diphosphopyridine nucleotide and diphosphopyridine nucleotide intermediate, respectively, to oxidized diphosphopyridine nucleotide. The addition of 2,4-dinitrophenol causes a rapid conversion of reduced diphosphopyridine nucleotide and the intermediate form to diphosphopyridine nucleotide because it produces both *I* and *X* in the hydrolytic reaction (4). The addition of adenosine diphosphate also causes a rapid appearance of oxidized diphosphopyridine nucleotide (but slower than that caused by addition of 2,4-dinitrophenol) because it produces free *X* in reaction (3*b*). It is likely that there is sufficient free phosphate in the mitochondria preparation so that reaction (3*a*) can proceed to the right. The ability of phosphate, which in reaction (3*a*) liberates *I* from $X \sim I$, to cause the appearance of diphosphopyridine nucleotide may be explained by assuming a slight uncoupling or hydrolysis of $X \sim I$ to yield free *X*.

The decrease in oxidized diphosphopyridine nucleotide and the increase in diphosphopyridine nucleotide intermediate but not in reduced diphosphopyridine nucleotide that occur on the addition of α-ketoglutarate or glutamate to liver mitochondria are explained by the reduction of diphosphopyridine nucleotide by the mitochondrial dehydrogenase followed by reaction (1). The increased amounts of both oxidized and reduced diphosphopyridine nucleotide that occur on the addition of β-hydroxybutyrate in the presence of magnesium is attributed to a reduction of diphosphopyridine nucleotide by the β-hydroxybutyric dehydrogenase followed by reaction (2). The free *X* needed for reaction (2) most likely results from a slight uncoupling by β-hydroxybutyrate.

The decrease in diphosphopyridine nucleotide with succinate is somewhat surprising since diphosphopyridine nucleotide is not a member of the succinic oxidase system. The increase in diphosphopyridine nucleotide intermediate but not reduced diphosphopyridine nucleotide may be explained by the formation of $X \sim P$ in the phosphorylation steps associated with succinate oxidation and the reversal of the high-energy-transfer steps associated with diphosphopyridine nucleotide (reactions 3*a* and 2) to form the diphosphopyridine nucleotide intermediate.

The conversion of reduced diphosphopyridine nucleotide to the energy-rich intermediate and the inhibition of diphosphopyridine nucleotide appearance by 0·8 m*M* amytal in the presence of adenosine diphosphate may be explained by the blocking of reaction (2) but not reaction (1) with low concentrations of amytal. Higher concentrations of amytal (1·8 m*M*) also block reaction (1). Thus, it is postulated that the primary site of amytal action is reaction (2).

I wish to express my thanks to Prof. E. C. Slater for his interest and helpful criticism, and to Miss Jet Moerdijk for her skilled technical assistance. This investigation was carried out during the tenure of a Life Insurance Medical Research Followship.

Further details will be published later.

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GENETIC CONTROL OF THE CYTOLOGICALLY DIPLOID BEHAVIOUR OF HEXAPLOID WHEAT

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COMMON wheat, *Triticum vulgare*, is a hexaploid species with 42 chromosomes in which the genomes of diploid wheat and of the diploid species *Aegilops speltoides* and *Aegilops squarrosa* are combined together[1-5]. There is considerable similarity between the chromosomes of these three diploids. Indeed, in hybrids between diploid wheat and *Aeg. squarrosa* and between diploid wheat and *Aeg. speltoides*, complete pairing at meiosis occasionally results in the formation of seven bivalents, although the mean bivalent frequency is somewhat less, being between three and four per cell[5,6]. Moreover, the attraction which results in bivalent formation in the hybrids is of such strength as to cause multivalent formation in tetraploids induced from them. However, each chromosome normally conjugates with its complete homologue at meiosis in *T. vulgare*, and only bivalents are formed. Thus, the pairing attractions between the equivalent, homoeologous, chromosomes of different genomes either no longer exists or is no longer expressed. Polyploid wheat has therefore evolved to behave cytologically as a diploid. Further, the shift has been of such efficiency that there is very little chromosome pairing even in 21-chromosome haploids of *T. vulgare*, in which intergenome pairing is not restricted by the affinity of complete homologues. The cytological distinctiveness of the equivalent chromosomes of different genomes is all the more striking in view of the close genetic relationships which have enabled Sears[7], by nullisomic-tetrasomic compensation, to recognize the seven homoeologous groups into which the complement of wheat can be arranged.

Recent results with various aneuploids have revealed something of the genetic control of the diploid behaviour of *T. vulgare*. The evidence centres on the derivatives of a 41-chromosome monosomic line, designated *HH*, which arose at Cambridge in the variety Holdfast. The formation of twenty bivalents and one univalent (Fig. 6) in *HH* monosomics is like the behaviour of all other monosomics of common wheat[8]. Meiosis is normal in the 42-chromosome segregants in the monosomic line, and in the 42-chromosome hybrids from crosses of *HH* monosomics to euploid plants of Holdfast. Therefore, the chromosomes of *HH* monosomics are structurally unaltered compared with those of Holdfast. One arm of the chromosome monosomic in the *HH* line is rather more than twice the length of the other, but the chromosome has not yet been positively identified relative to the numbering based on the variety Chinese Spring.

Monosomics of *HH* have been used in crosses with 44-chromosome plants which had the full complement of wheat chromosomes plus a single pair of rye chromosomes. From these crosses five 20-chromosome, nulli-haploid, plants have been obtained, which, by the nature of their origin, must have had the haploid complement of Holdfast minus the chromosome which is monosomic in the *HH* line. The nulli-haploids arose in (*a*) the F_1 of the cross *HH* monosomic × rye chromosome III disomic addition, and in (*b*) the F_2 of crosses of *HH* monosomic × rye II, or rye III, disomic additions[9]. All the F_1's which produced nulli-haploids in F_2 had twenty bivalents composed of wheat chromosomes and the *HH* chromosome and a rye chromosome as univalents. In each situation, therefore, the 20-chromosomes in the embryo sacs which functioned parthenogenetically must have been those which had segregated from bivalents—that is, all the wheat chromosomes except *HH*.

The meiotic pairing of the *HH* nulli-haploids has been compared with the pairing in 21-chromosome euhaploids of Holdfast. The meiotic behaviour of the euhaploid plant listed in Table 1 was similar to that of twelve other 21-chromosome plants of Holdfast examined over a period of four years. The number of bivalents in these plants never exceeded four, with a mean frequency of between 1·3 and 1·7 per cell, and trivalents were rare (Fig. 1). There was usually only one chiasma per bivalent.

By contrast, in the *HH* nulli-haploid enumerated in Table 1, which is typical of five such plants examined in two successive years, the mean bivalent frequency exceeded the maximum observed in euhaploids. Trivalents were quite frequent with as many as five in some cells (Fig. 3), although there was never more than one per cell in the euhaploids. Very many more chromosomes per cell, a mean of 11·0 compared with a mean of 2·9, were involved in chiasma-associations and a much higher frequency of closed bivalents and of 'pan-handle' trivalents resulted from more intimate pairing. As many as nineteen of the twenty chromosomes of the nulli-haploid have been observed in various associations simultaneously, although never more than nine were involved in associations in the same cell in euhaploids.

The most reasonable hypothesis to account for these observations was that the deficient chromosome carried a gene, or genes, which restricted

Table 1. Meiotic Pairing in Euhaploid and *HH* Nulli-haploid of *T. vulgare*

Type	Chromosome No.	Cells	Mean pairing			Proportion of bivalents as rings	Conjugated chromosomes per cell	
			Bivalents	Trivalents	Quadrivalents		Mean	Range
Euhaploid	21	100	1·38 ± 0·09	0·07	—	0·00	2·86 ± 0·23	0–9
Nulli-haploid	20	75	4·16 ± 0·12	0·86 ± 0·03	0·02	0·23	10·95 ± 0·33	4–19

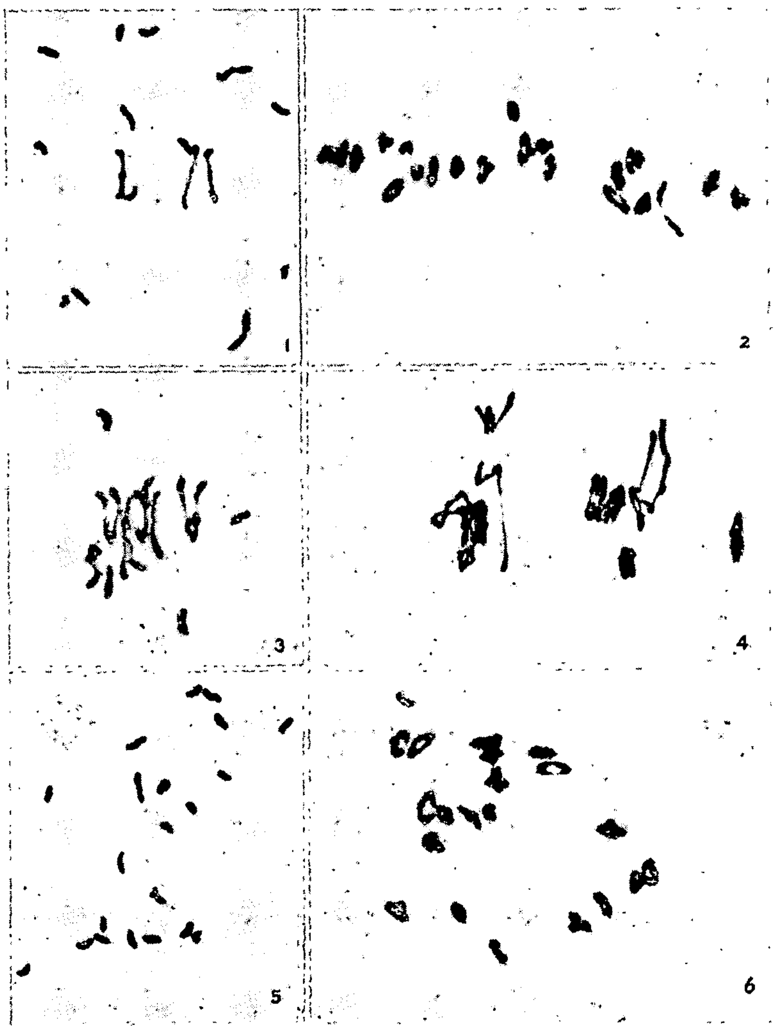
intergenomic, homoeologous, pairing ; the alternative being that association between randomly distributed duplicate segments was normally inhibited. On either view, there being no other independent mechanism, in the absence of the pairing restriction normally undetected affinities were expressed. Crucial evidence that the pairing was homoeologous rather than random was afforded by the high frequency of trivalents and the infrequency of quadrivalents.

If homoeologous pairing could take place in *HH* nulli-haploids, it was argued that 40-chromosome nullisomics deficient for the *HH* pair should deviate from the strictly bivalent-forming regime of *T. vulgare*. Consequently, three *HH* nullisomics have been examined. All had large and frequent multivalents, and associated univalents, at meiosis. No method has yet been found of consistently preparing well-spread pollen mother cells of this material, but the complexity of the behaviour is readily apparent (Fig. 4). More than half the cells have at least one multivalent, usually a quadrivalent, and many have several. Associations of three, four, five and six are common, but no higher multivalents have been observed. However, the greater the number and size of multivalents the less is the chance of disentangling the snarl, so there is danger of observational bias. No doubt, also, there are homoeologous, or allosyndetic, bivalents which would be undetected unless markedly heteromorphic. The magnitude of the meiotic disturbance is therefore hard to assess ; nevertheless, it is clear that, in the absence of the *HH* chromosome, *T. vulgare* ceases to be a stable bivalent former, a classical example of the autosyndetic pairing allohexaploid, and behaves as an intermediate, auto-allopolyploid.

The diploidizing mechanism is effective in the hemizygous state in monosomics and in euhaploids. Furthermore, in a haploid plant which had twenty normal wheat chromosomes plus the iso-chromosome formed from the long arm of the *HH* chromosome (Fig. 5), meiotic pairing was the same as in euhaploids. Moreover, there was no multivalent formation in a 41-chromosome monosomic which had twenty normal pairs of Holdfast chromosomes and in which the *HH* chromosome was represented only by a single telocentric of the long arm. The long arm alone is thus effective in prohibiting homoeologous association ; but no evidence is available on the effects of the short arm alone. It may be that both arms have genes with equally effective control over the pairing behaviour, but this seems unlikely. The control of bivalent formation is probably restricted to one arm, and may indeed be effected by quite a localized region.

The implications of these results are both theoretical and practical. First, there has been considerable discussion on the methods by which many polyploids have attained their cytologically diploid character, with its obvious advantages in fertility and genetic stability. Several authors have favoured the theory that this situation has been achieved by the selective accumulation of many small changes of chromosome structure, which lead to the divergence of homoeologues. However, the selection of the localized product of a single mutational step, such as seems likely to have happened in wheat, is very much simpler to envisage, and would clearly be a more rapid and efficient process. To compare the frequencies of the genetical, or cytological, determination of diploid meiotic behaviour, other allopolyploid species should be examined for evidence of a mechanism similar to that in wheat.

Secondly, knowledge of the pairing restricting mechanism may be useful in wheat improvement.



First metaphase of meiosis in Feulgen- and orcein-stained squashes of pollen mother cells of various derivatives of *T. vulgare*

(1) 21-Chromosome euhaploid with 4 bivalents (one widely stretched) and 13 univalents. (2) Euploid with 21 bivalents. (3) 20-Chromosome *HH* nulli-haploid with one 'pan-handle' and 4 chain trivalents, one bivalent and 3 univalents. (4) 40-Chromosome *HH* nullisomic with one ring of six, 2 chains of four and 13 bivalents. (5) 21-Chromosome haploid in which the *HH* chromosome is an isochromosome of the long arm ; one stretched bivalent, 18 normal univalents and the isochromosome paired interbrachially with two chiasmata. (6) 41-Chromosome *HH* monosomic with 20 bivalents and one univalent. (× 770)

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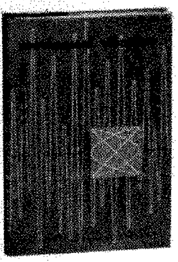

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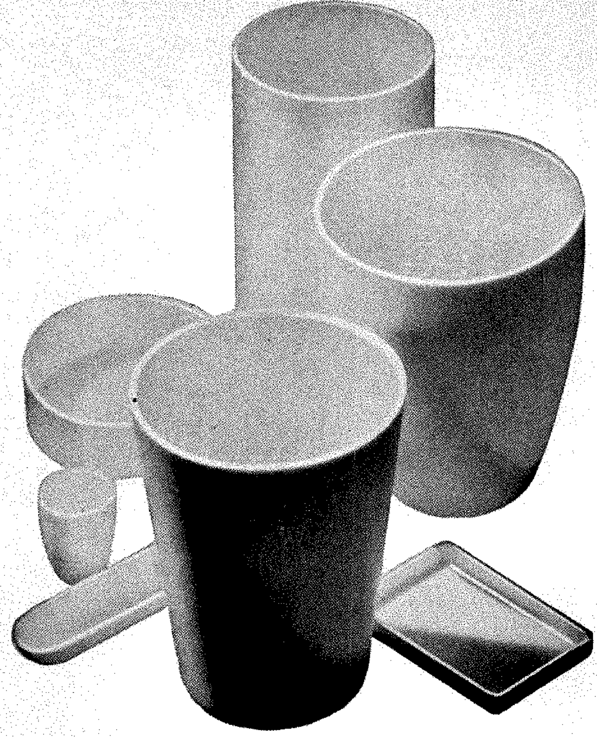

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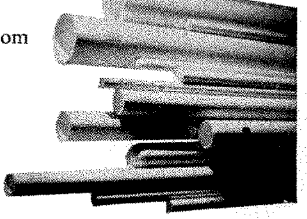

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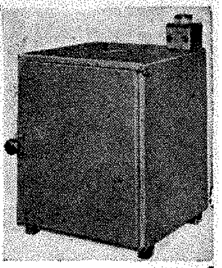

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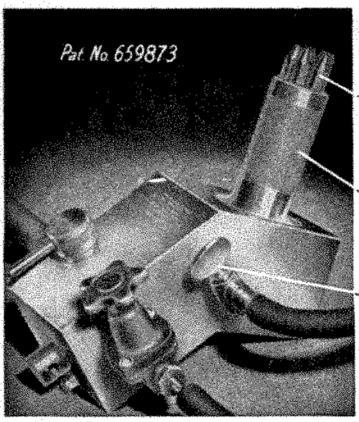

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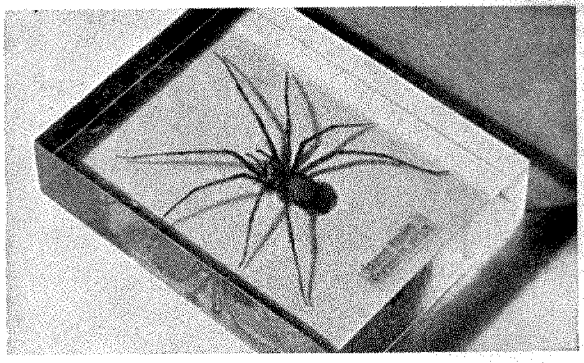

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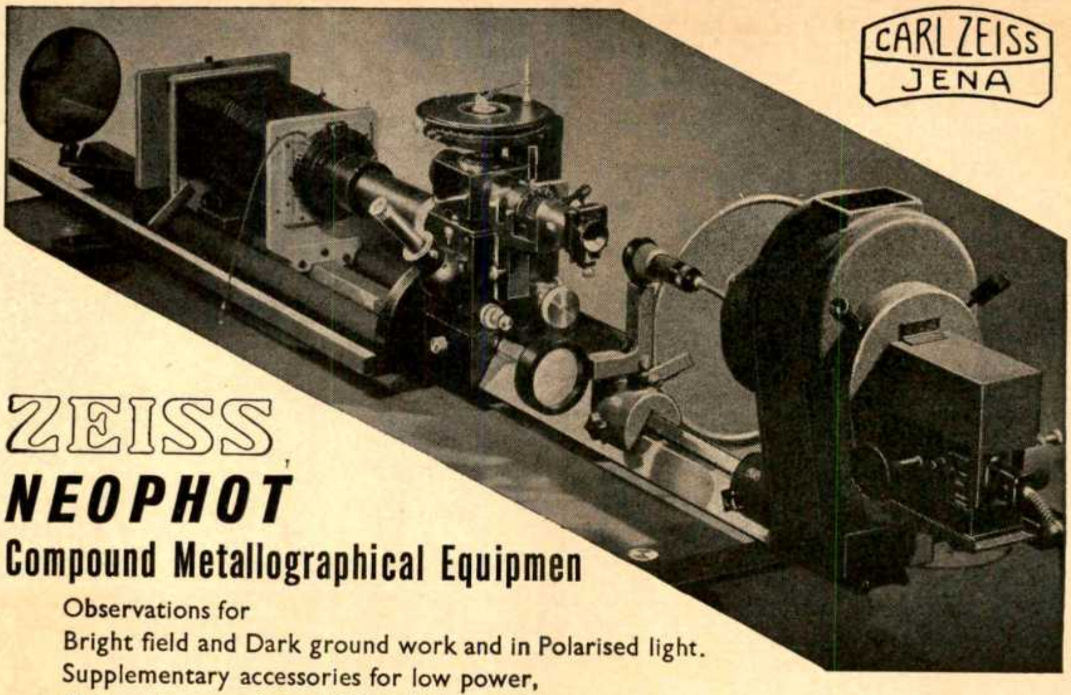

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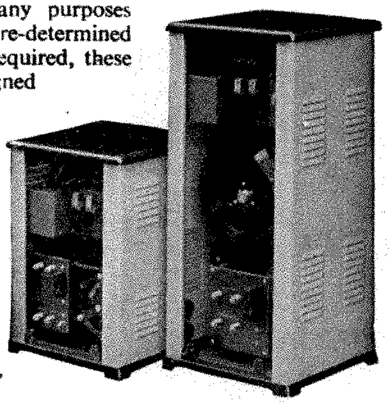

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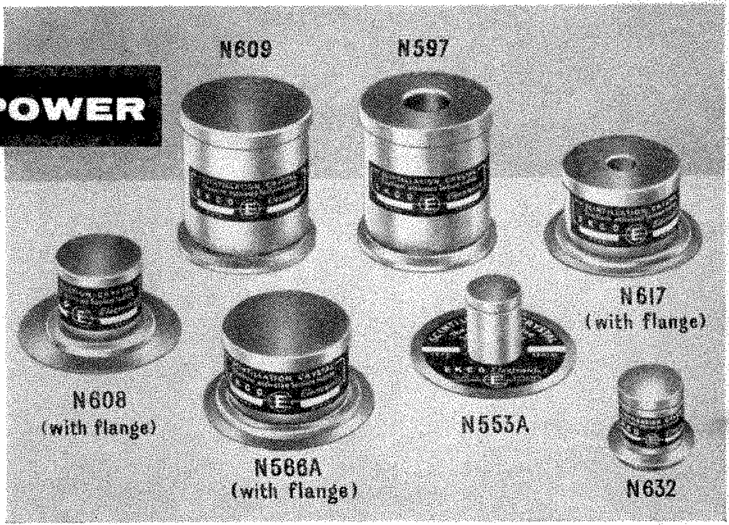

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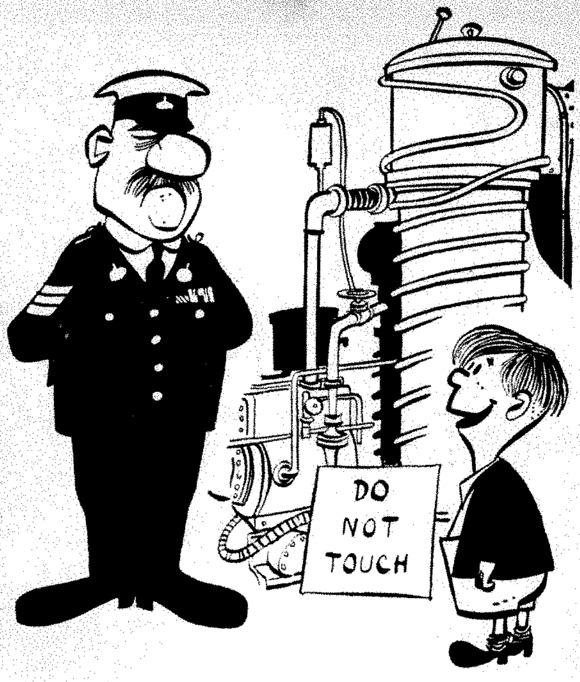

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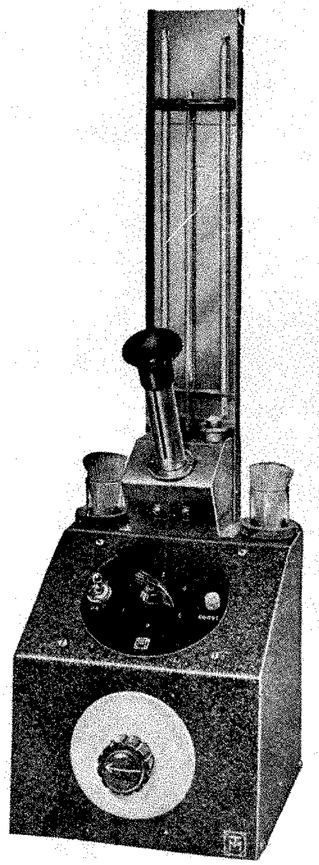

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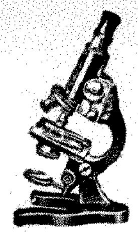

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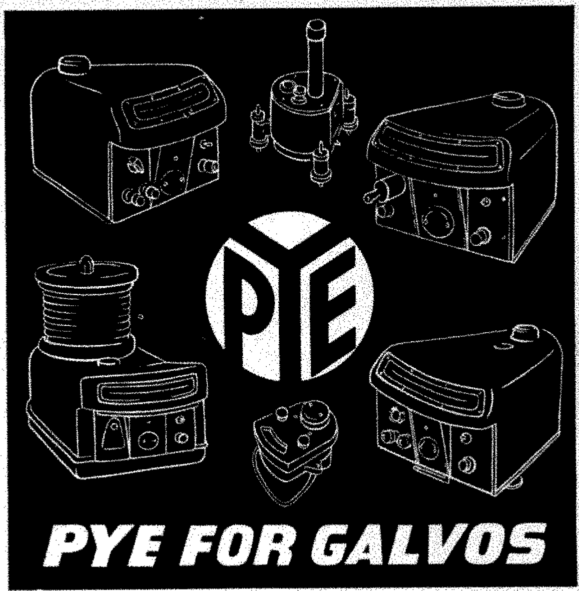

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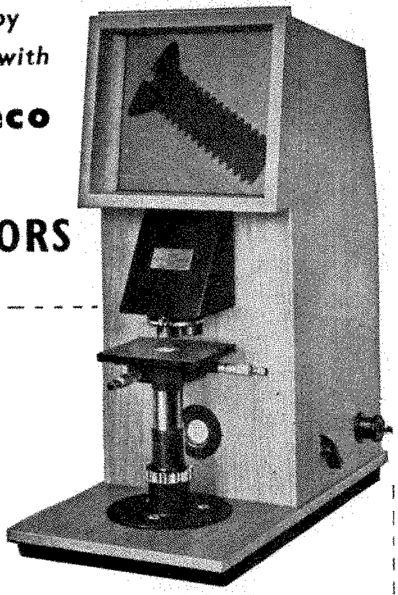

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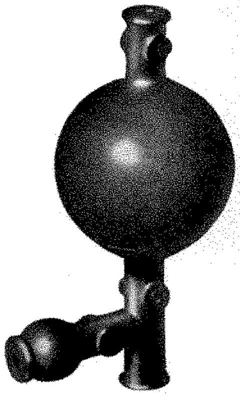

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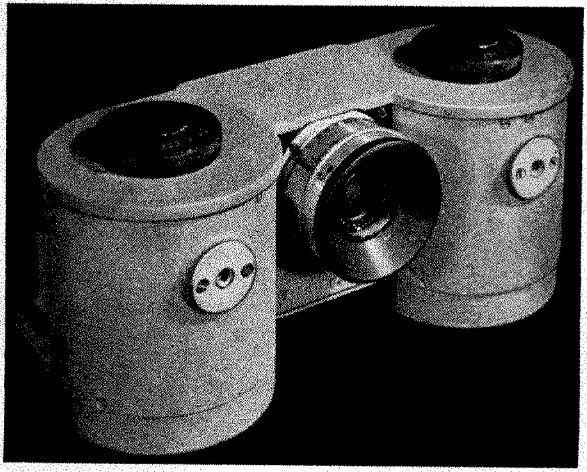

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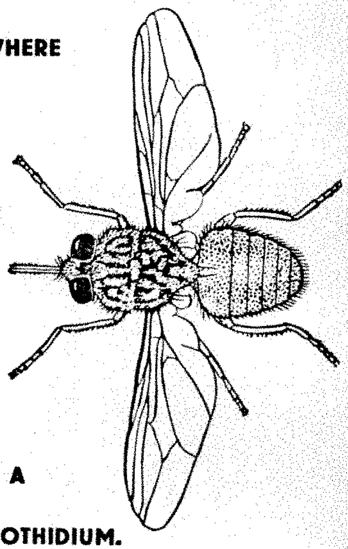

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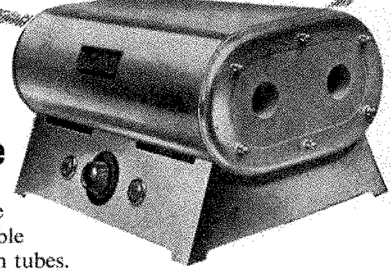

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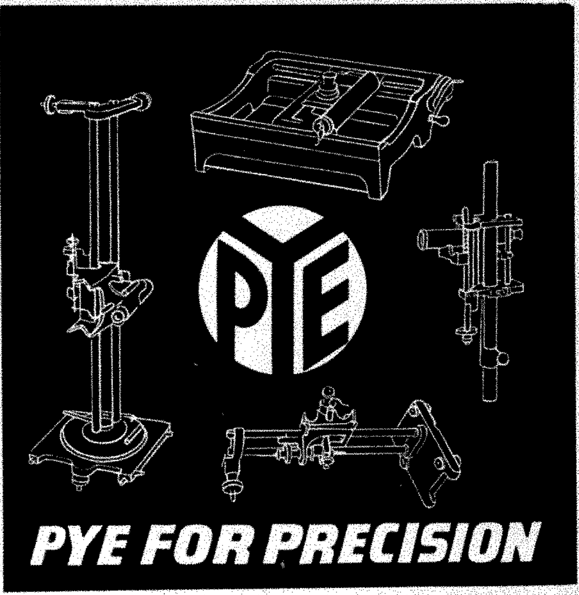

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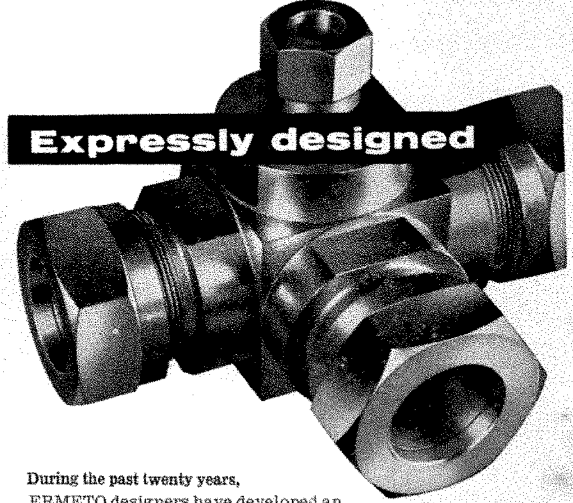

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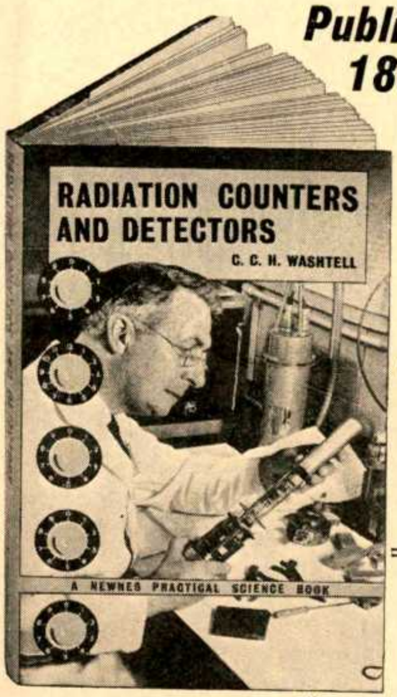
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The utilization of related diploid species, for example, in the genus *Aegilops*, in wheat breeding is hampered because the chromosomes of the diploids do not pair with those of wheat, in intergeneric hybrids. To overcome this obstacle, Sears[10] was forced to use X-rays to induce the translocation of a disease-resistance gene of *Aeg. umbellulata* on to a wheat chromosome, and others[9, 11,12] have been compelled to explore alien chromosome addition and substitution lines. However, this intergeneric allosyndetic pairing may well take place in the absence of the *HH* chromosome, just as it does between chromosomes of the different genomes; alien genes could then be introduced into wheat chromosomes by normal recombination. Critical hybrids of this constitution can be extracted from crosses of *HH* monosomics by the appropriate diploid.

Finally, nullisomic plants of this constitution may be used either within single varieties or in intervarietal hybrids in 'intergenome exchange' breeding. Thus a useful gene which showed a dose effect could be obtained duplicated or triplicated, represented on each chromosome of the homoeologous group. The chromosome structure within a variety could be re-patterned by breeding from *HH* nullisomics. Further, if an *HH* nullisomic were also an intervarietal hybrid, the release of variation, and the range of segregation in later generations, would be very much greater than from a euploid hybrid. Thus, the *HH* nullisomic may afford access to otherwise unavailable genetic variation.

However, the exploitation of *HH* nullisomics depends upon their fertility. There is no natural self-fertility, but a reasonable seed set has been obtained by pollinating *HH* nullisomics with Holdfast euploids, although the reciprocal cross has been unsuccessful. There were several large multivalents at meiosis in the one 41-chromosome derivative, so far examined, of an *HH* nullisomic pollinated by a euploid. The *HH* chromosome regained from the euploid pollen was always a univalent, and homoeologous pairing must have been prohibited by its presence. The multivalents were thus indicative of translocation heterozygosity, the outcome of homoeologous pairing in the nullisomic parent. Homozygotes for new structural conditions can be derived from such plants, although further back-crossing may first be necessary to reduce the extent of structural alteration.

Knowledge of the situation described already begins to make plain some of the problems of wheat cytogenetics and perhaps of polyploidy in general. Further investigation cannot fail to extend this advantage and may well contribute to the cytogenetic manipulation of wheat for practical breeding purposes.

The interest of Dr. G. D. H. Bell in the development of this work is gratefully acknowledged.

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SUCROSE CRYSTAL INCLUSIONS

By H. E. C. POWERS

Tate and Lyle, Ltd., Thames Refinery, London, E.16

TWO years ago I reported[1] the presence of water inside the sucrose crystal as a normal phenomenon, the percentage varying between wide limits. Measurements of vapour pressure, taken before and after crushing, demonstrated this qualitatively, but at that time no adequate quantitative analytical procedure was available for precise measurement. Two new methods have since been developed in our research laboratories[2]. The evidence obtained so far indicates that with refined sucrose crystals of the normal size of granulated sugar, the internal water ranges at least from 0·01 to 0·04 per cent, while with large crystals approaching an inch in length, the range of internal water may be ten times greater (0·1 to 0·4 per cent).

Since this included water is due to the 'growing in' of mother syrup by the layers during the growth of the crystal[1], the composition of this internal syrup will be essentially that of the mother syrup.

Given the composition of the mother syrup, together with the amount calculated from the included water, it is possible to estimate the amounts of the various non-sucrose constituents held in syrup inclusions.

Results obtained so far suggest that water-soluble organic colouring matter is held entirely in these syrup inclusions, but that certain ionized salts are frequently found in far higher proportion than that calculated on the basis of included syrup. Calcium and potassium salts seem to be thus held, and in particular, the potassium salt of imidodisulphonic acid[3], and calcium magnesium aconitate in beet and cane sugars respectively. It is not known whether these are deposited as crystals which are then built-in by the layer growth, or whether they are held by some ionic or molecular similarity of structure with some part of the sucrose molecule.

Non-crystalline insoluble matter may also be 'grown in' by the layer growth, as, for example, starch, which is found in the sap of certain strains of sugar cane. This appears to be attracted towards the growing crystal face, since after several successive crystallizations, the starch is found in the crystals in a higher ratio to soluble salts than in the original juice. Certain colloids appear to act similarly.

Further study of sucrose crystals under the microscope has also revealed gaseous inclusions. By watching chosen specimens in the act of dissolving under the microscope, when an inclusion of syrup is breached, the heavy syrup may be seen streaming downwards, whereas when a gaseous inclusion is breached a bubble may be seen to strain like a balloon, then to break away and rise rapidly to the surface. The probable origin is that air dissolved in the original crystallizing syrup became supersaturated and formed as bubbles on the growing face. These were then overgrown by the layers. One obvious effect of these inclusions is to explain the widely varying figures given in the literature for the specific gravity and melting point of sucrose—1·58–1·60 gm./cm.^{3} and 160–186° C., respectively. By selecting two crystals under the microscope with maximum and minimum visible inclusion and determining their specific gravities, we have obtained figures of 1·582 and 1·594 gm./cm.^{3} respectively.

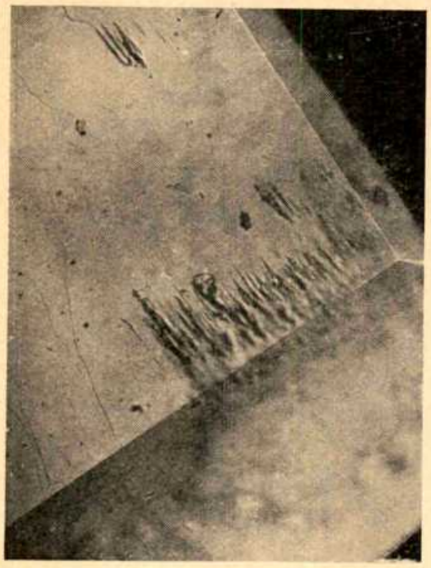

Fig. 1. Fjord-type inclusions (note also layer growth)

These fluid inclusions take several distinctly different physical forms (see Figs. 1–5).

(1) A fjord-like form, the position of which in the crystal appears to be completely random, though frequently several are present roughly parallel to one another.

(2) A rather symmetric form, of which the most perfect and complete is usually referred to as the 'hour-glass' shape, since when viewed toward the 100 face, the familiar hour-glass shape is apparent. Sometimes only a section of this may be present.

(3) Orderly patterns indicating some symmetry—sometimes, but certainly not always, the result of *Einwurf* boiling (using crystals from one boiling as seed for a second).

(4) Veil-like systems, in appearance suggesting a wisp of gossamer flicked through the crystal, with no respect for the axis.

(5) Local clouds or drifts of approximately spherical droplets in diameter from 100μ down at least to 1μ.

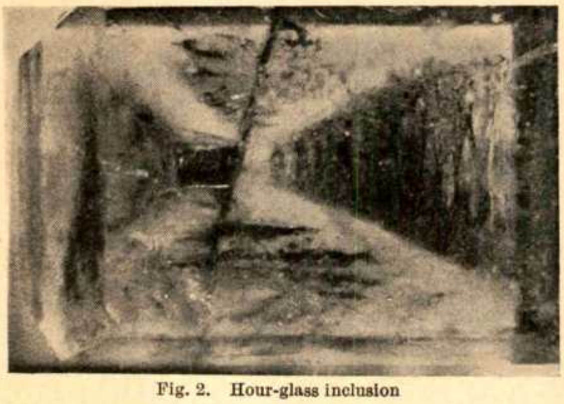

Fig. 2. Hour-glass inclusion

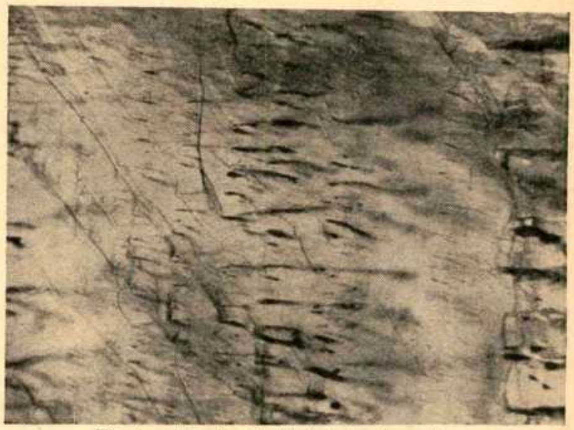

Fig. 4. Complex rhythmic inclusion pattern

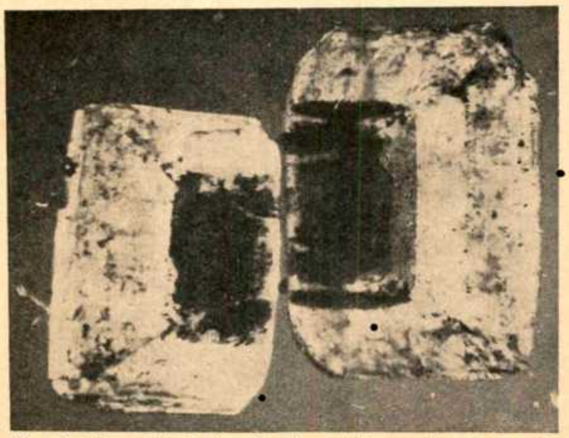

Fig. 3. *Einwurf* inclusion, showing evidence of lower growth-rate in one direction

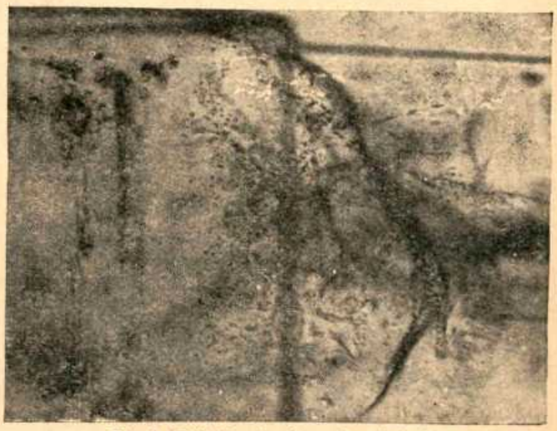

Fig. 5. Veil, showing hour-glass inclusions

The evidence suggests that the first three are the result of layer growth 'building-in' liquor or air locally, and a fortunate micro-film shows the fourth to be the result of a sudden crack, due to growth or temperature strain. Whereas the initial veil consists of a continuous film layer, this appears to be unstable, and I am fairly confident that, if conditions of temperature and time permit, the film slowly 'congeals' to a more stable condition. The first stage reminds one of a network of isthmuses; the later stage is the network of detached droplets. This I have classed as the distinct type 5, since it is possible that some of these droplets may have been 'grown in', as with type 1.

It is interesting that layer growth is able to proceed around such dissimilar foreign intrusions as thread, wire, sheets of metal, local spots of liquor at lower supersaturation and even bubbles of air, and that without apparent disturbance to the crystal symmetry. Dr. A. F. Seager originally directed my attention to the fact that the major inclusions are normally to be found in that portion of the crystal which has grown most rapidly, in conformity with the usual belief that rapid growth increases the tendency to form inclusions. I have now found many instances of this phenomenon.

Another lucky micro-film suggests that one part of one face of a crystal may exhibit a local 'spurt' in the rate of growth. This may play a part in the formation of the larger inclusions. Artificial inclusions have been made successfully by boring a hole through a large crystal, then immersing it in a supersaturated solution, when the two exits may be sealed, thus closing the liquor-filled tunnel.

The evidence, both with mosaic and with the many types of inclusion, indicates that the interior of sucrose crystals normally exhibits great local variation in structure.

So much crystallographic research is in the nature of a post-mortem upon geological crystals formed in the distant past. It would appear that the study of such a crystal as sucrose in active growth should provide the key to several features common to many crystalline materials.

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USE OF TWO PROPERTIES OF THE VIRUS OF FOOT-AND-MOUTH DISEASE IN STUDIES OF ITS MULTIPLICATION

By SHEILA F. CARTWRIGHT and H. V. THORNE

Research Institute (Animal Virus Diseases), Pirbright, Surrey

In a previous study of the multiplication of the virus of foot-and-mouth disease in cultures of tongue epithelial cells[1], it was found that infective virus remained bound to the cells during the latent period, that is, up to 2–2½ hr. after infection even after treatment of the cells with specific antiserum. The number of infective units of virus (*ID*50/ml.) was approximately equal to the number of cells producing virus; it was therefore not possible to decide whether this infectivity was due to virus other than that producing infection, adsorbed in such a way that it resisted the action of antiserum, or to virus which after entering and infecting the cell remained infective. Since in studies of phage and other viruses[2–6] the infecting virus has been shown to become non-infective after penetration, it was important to decide between these possibilities.

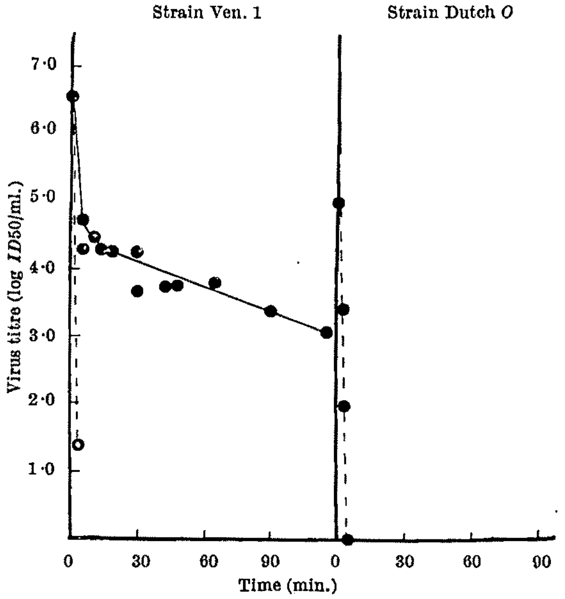

Fig. 1. The *p*H-inactivation of the Ven. 1 and Dutch *O* strains of the virus of foot-and-mouth disease; ●—●, *p*H 6·0; ○—○, *p*H 5·7

Two properties of the virus of foot-and-mouth disease have been utilized for this purpose. In a paper by Cartwright and Thorne[7], the resistance of the virus to sodium dodecyl sulphate and other detergents is described, with its application to the lysis of tongue epithelium and pig kidney cells and extraction of virus throughout the growth-cycle. Sodium dodecyl sulphate has advantages in this type of work over other methods of disrupting cells in the rapidity and completeness of its action. With this reagent and again using antiserum to inactivate extracellular virus, infectivity of the same order was still found during the latent period with both cell types.

Secondly, the well-known instability of this virus at *p*H values below neutrality[8–10] suggested lowering the *p*H of the culture as an alternative means to the use of antiserum or washing. The possible advantages of *p*H change are the rapidity and completeness of the inactivation, and the ease of penetration of the hydrogen ion into the cell surface. The results of using *p*H inactivation in conjunction with the sodium dodecyl sulphate method of disruption to determine virus remaining associated with the cells are reported here.

The characteristics of the inactivation of the two strains of virus used, Ven. 1 and Dutch *O* (1957), at relevant *p*H values are shown in Fig. 1. At *p*H 6·0 the Ven. 1 strain is inactivated at a slower rate than Dutch *O* and in addition a small fraction of the virus population (~ 1 per cent) is inactivated at a much slower rate than the main fraction. A similar fraction was found in the strain studied by Bachrach *et al.*[10]. At *p*H 5·7, however, the rate of inactivation is such that 99·9 per cent of both Ven. 1 and Dutch *O* virus is inactivated in less than 1 min.

In the experiments with cell suspensions the following procedure was used. Suspensions of tongue epithelial and pig kidney cells were exposed to seed virus (1–100 *ID*50/cell) for 30 min. at 37° C., when the suspension was adjusted from the normal *p*H (7·6) to *p*H values in the range 5·0–6·0 either by sedimenting the cells and resuspending in 0·02 *M* acetate-buffered medium (Tyrode's + 0·5 per cent lactalbumin hydrolysate) or rapidly by the addition of 0·1–1·0 *M* acetic acid. After 5–70 min. the *p*H was restored to 7·6 either by sedimenting the cells and resuspending in normal medium or by the addition of 0·01 *N* sodium hydroxide or *p*H 7·6, 0·04 *M* phosphate buffer. A portion was then titrated by inoculation of unweaned mice[11] to determine the number of infected cells, and a portion, treated with an equal volume of 1·0 per cent sodium dodecyl sulphate in phosphate buffer to destroy the cells, was titrated to determine residual infective virus. The remainder was incubated at 37° C. and titrated to determine the yield of virus after multiplication.

From the representative results in Table 1, the virus associated with the cells after infection with the Ven. 1 strain of virus is now seen to be of the order of 1 infective unit/100 infected cells, while the virus produced remains normal, within the limits of error of titration (± 0·3 log unit), for *p*H treatments at 5·5 and above up to 15 min. Below *p*H 5·5 most of the cells become non-viable in the medium used. Longer times at low *p*H appear to slow down the multiplication of virus, although the eventual yield is normal; this is now being investigated.

Table 1. Latent Period Infectivity. Strain Ven. 1 in Tongue Epithelial Cells

*p*H	Log No. cells/ml.	Infected cell titre Log No./ml.	Per cent ratio cell-associated virus / Infected cell titre	Yield *ID*50/ml.
6·0	6·3	5·1	0·5	7·6
5·9	6·6	5·0	1·0	—
5·7	6·7	4·9	1·0	7·6
5·5	6·8	5·3	0·1	7·8

When the virus is kept in contact with the cells for times less than 30 min. before rapid adjustment to low *p*H (5·7), the cell-associated virus at short adsorption times is reduced still further (Fig. 2), to about 1 infective unit/10^4 infected cells, although the number of infected cells is the same within the experimental error after 1 min. as after 30 min. adsorption. There is a steady increase in the cell-associated virus with time of adsorption until the normal level after 30 min. adsorption is reached. No increase in the cell-associated virus with time was observed with the Dutch *O* strain of virus. It is possible that the greater cell-associated infectivity with the Ven. 1 strain is related to the heterogeneity of this strain towards *p*H inactivation.

These experiments show that the virus of foot-and-mouth disease becomes non-infective on entering the cell. A rough estimate of the rate at which virus enters the cell and becomes non-infective can also be made. The number of infected cells after an adsorption time of 1 min., followed by lowering the *p*H, was shown to be of the same order as after a 30 min. adsorption period. Determination of the Dutch *O* strain virus surviving after increasing times at *p*H 5·7 showed that the extracellular and adsorbed virus was reduced from a total of about $10^{7·7}$ *ID*50/ml. to $10^{2·5}$ *ID*50/ml. (1 *ID*50/100 infected cells) in less than 30 sec. In addition, the action of sodium dodecyl sulphate is so rapid that no appreciable penetration could occur after *p*H treatment. It can therefore be concluded that adsorption and penetration must occur in less than 1 min. at 37° C.

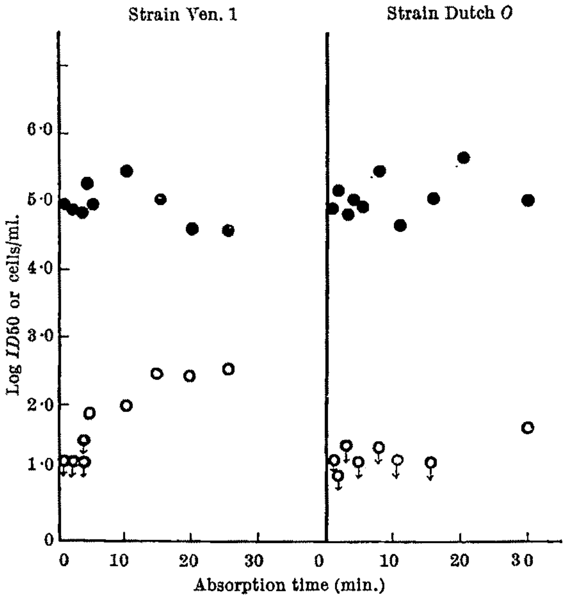

Fig. 2. The number of infected tongue epithelial cells and titre of cell-associated virus resulting from adsorption of the Ven. 1 and Dutch *O* strains of the virus of foot-and-mouth disease at 37° C. (seed virus $10^{7·8}$ *ID*50/ml.; cells $10^{6·6}$ ml.; ↓ represents titre ≮ that indicated). ●, Infected cells; ○, cell-associated virus

The apparently high level of adsorbed virus resistant to antiserum[1] may be related to the small proportion of cells which become infected in this system, since when this virus is expressed as a proportion of the total number of cells it is comparable with the levels of cell-associated virus in systems, such as that of the virus of Newcastle disease in chick embryo lung epithelial cells in which all cells are infected[12].

The results reported here indicate that by making use of the instability of the virus of foot-and-mouth disease at low *p*H in conjunction with its resistance to sodium dodecyl sulphate, further information on the adsorption and penetration of virus and on the succeeding stages of virus multiplication should be obtained.

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LETTERS TO THE EDITORS

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Carcinogenic Activity and O-Alkylation

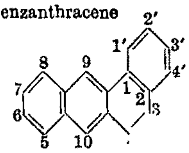
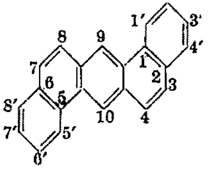
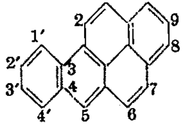
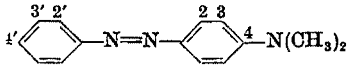
It is well known that many natural products, flower pigments, essential oils, alkaloids, etc., contain methoxy-groups, and that some of these compounds show remarkable biological activities, for example, colchicine, mescaline, etc. Despite the enormous amount of work done on the correlation of biological activity with the chemical structure, surprisingly little attention has been devoted to the biological effects connected with O-methylation of phenolic groups (compare, for example, Sexton[1]). Yet examples of its influence have been known for a long time (for example, morphine and codeine). The situation is likely to change in view of the recent discovery that O-methylation can occur in the animal body[2]; the reverse process, O-demethylation was observed in mammals about twenty years ago[3]. In view of the finding that the methyl group of methionine is also involved in O-methylation[4] the knowledge acquired from the study of N-methylation will no doubt help in the understanding of the interrelation of these two types of reactions.

With reference to carcinogenic activity, I was first impressed by the decisive part which O-methylation can play when the methylation product of the almost inactive phenolic metabolite of 3 : 4-benzopyrene produced tumours in mice[5]. Pure 8-methoxy-3 : 4-benzopyrene was then synthesized[6] and proved to be one of the most effective carcinogens for the skin and for the subcutaneous tissues of both mice and rats, surpassing in this respect the parent hydrocarbon[7]. Carcinogenic activity, though of a lesser degree, is exhibited by several other isomeric methoxy-3 : 4-benzopyrenes and also by methoxy-derivatives of other polycyclic hydrocarbons[8] (Table 1). The methoxy-groups, as well as the methyl-groups, often increase the efficacy of the hydrocarbon, but the effect depends to a striking degree on the number of the methoxy-groups and on the positions of substitution. The paucity of available data do not yet permit generalizations to be confidently made. Thus, methyl ethers at metabolically oxidized positions are not necessarily the most active: 4′-methoxy-1 : 2-benzanthracene was inactive, while the 3-, 5- and 10-isomers produced tumours.

Restoration or increase of carcinogenic activity by O-methylation is not confined to polycyclic aromatic hydrocarbons, but appears to be more generally encountered[9] (Table 1). Some examples have been reported recently among compounds representing 'remote' carcinogens, which usually induce tumours not at the site of application but in internal organs, such as liver, bladder, etc. It is not unlikely that the actual carcinogens are formed when these compounds are metabolized in the body. Indeed, in the case of some aromatic amines, the metabolic oxidation products, *o*-hydroxamines, proved to be 'local' carcinogens, when implanted in the mouse bladder. Only very few of their methyl ethers have so far been tested, and these appear to be more active than the hydroxy-compounds. The fact that 1-methoxy-2-aminonaphthalene, 3-methoxy-4-aminodiphenyl and 3-methoxy-4-aminostilbene have been reported carcinogenic[9] is of significance. It would be of interest to know whether all these compounds show 'local' carcinogenic activity when applied to tissues other than the bladder.

It is of particular interest that recently some *o*-hydroxamines which are normal intermediary body metabolites, such as 3-hydroxykynurenine, 3-hydroxyanthranilic acid, and 2-amino-3-hydroxy-acetophenone have been reported to produce tumours

Table 1. Comparison of Carcinogenic Activity of some Hydroxy- and Methoxy-Derivatives of Carcinogens

Compound	Carcinogenic activity	Hydroxy-derivatives Position of substitution	 Carcinogenic activity	Methoxy-derivatives Position of substitution	 Carcinogenic activity
1 : 2-Benzanthracene 	±	4′ 3 8 10	– ± – –	4′ 3 5 10 3 : 10-di 9 : 10-di	– ++ ++ +++ – –
1 : 2–5 : 6-Dibenzanthracene 	+++	9 – 3′ : 7′-di 4′ : 8′-di 2′ : 6′-di	– – – –	9 3 9 : 10-di	++ – –
3 : 4-Benzopyrene 	+++	4′ 2 5 6 8	– – – + ±	4′ 5 6 (or 7) 8 5 : 8-di 5 : 10-di	– ++ ++ ++++ – –
4-Dimethylaminoazobenzene 	+++	2′ 3′ 4′ 2 3	– – – – –	2′ 3′ 4′	++ +++ ++

when tested by the bladder implantation method. The 8-methyl ether of xanthurenic acid was again more effective than the latter, 4 : 8-dihydroxyquinoline-2-carboxylic acid[9].

More data are urgently needed on the biological activities of methyl ethers of phenolic compounds normally present in tissues, and on the conditions which may affect the equilibrium between metabolic O-methylation and O-demethylation—evidently of paramount importance for carcinogenic activity.

The evidence already available is sufficient to warrant further exploration for carcinogenic activity also of other alkyl ethers of such phenolic compounds. In this connexion the finding of carcinogenic activity among some alkylating agents is of interest. These alkylating agents have been studied in connexion with the cross-linkage hypothesis of carcinogenesis[10]. Their role as agents which could alkylate phenolic compounds deserves to be considered.

I wish to thank Dr. J. W. Cook and Dr. J. M. Barnes for very valuable discussions.

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Carnosine Phosphate as Phosphate Donor in Muscular Contraction

UNDER the above title Goodall[1] showed that a mixture of carnosine di- and mono-phosphates has a relaxing action practically identical with that of creatine phosphate on the glycerol-extracted muscle fibre. He raised the question of the presence and role of this substance in muscle, and pointed out that its non-detection so far may be because it is so much more acid-labile than creatine phosphate[1,2].

In order to provide the energy for the 125 gm. cm. of external work done per gram of muscle in a typical twitch a 'high-energy' phosphate compound would have to be present at a concentration of at least 0·25 µmole per gm. muscle. (This calculation takes a low value for the external work done, neglects the heat produced in the muscle, assumes 100 per cent efficiency in energy transduction and a high value (12,000 cal.) for the energy delivered per mole of compound broken down.) A more probable figure would be 0·5 or more µmole per gm. muscle[3,4]. Since preliminary experiments showed that large amounts of carnosine phosphates were not present in muscle the following procedure was employed. The very slow, thin, paired, striated, retractor penis muscles of turtles were used. This muscle can be frozen in the relaxed state without change in length, and measurements of the longitudinal electrical conductivity with thermally insulated electrodes showed that the centre of the muscle was frozen in less than one-fifth of the time needed for a normal contraction at 0° C. This means that there was no time for a possible isometric contraction of the internal parts of the muscle to occur during freezing, which might have vitiated the results. The muscles were immersed at 25° C. for a total of 4 hr. in a physiological salt solution containing radioactive inorganic orthophosphate. After 2 hr. they were stimulated electrically several times and allowed to recover. This procedure causes a chemical turnover of all phosphate compounds involved in muscle contraction and ensures a close approach to equality in the specific radioactivities of the labile phosphate compounds in this tissue[5]. Thus if carnosine phosphates were present in even as low a concentration as 0·25 µmole per gm. muscle the total radioactive counts per minute in this compound would have to be at least 0·25/13, that is to say, 0·019 times the total radioactivity in the creatine phosphate which is present at a concentration of 13 µmoles per gm. muscle.

At the end of the incubation period the muscles were attached to isotonic levers, cooled to 0° C., frozen in the relaxed state in melting dichlorodifluoromethane (– 155° C.), and powdered at – 198° C. Carrier quantities of a mixture of non-radioactive synthetic carnosine di- and mono-phosphates[2] were added to preserve any such radioactive material in the tissue from possible losses during isolation. The powder was extracted at 0° C. in 20 per cent v/v

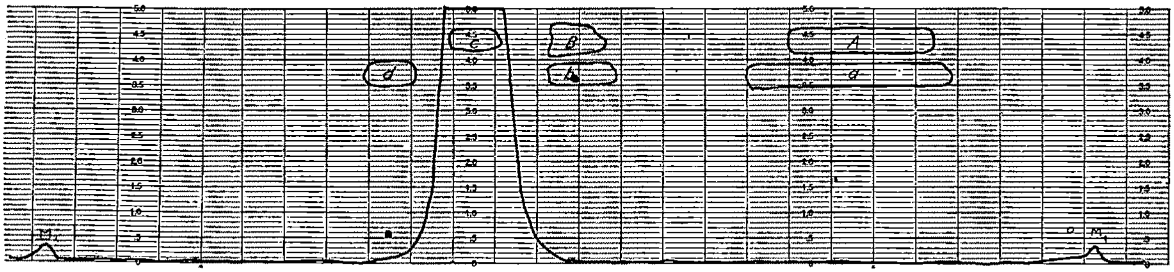

Fig. 1. Distribution of radioactivity in muscle extract treated with barium. *A*, *B* and *C* correspond to the positions on the chromatogram of carnosine diphosphate, carnosine monophosphate and creatine phosphate respectively as shown by an acid-molybdate spray for phosphorus. *a*, *b* and *d* correspond to carnosine diphosphate, carnosine monophosphate and tissue carnosine as shown by a spray of *p*-nitrobenzenediazonium fluoborate after treatment with acid *in situ*. M_1 and M_2 are radioactive marker spots; *O* is the origin. Full-scale deflexion of the scanner at the sensitivity used for this graph was 3,000 c.p.m. The R_F of the creatine phosphate is 0·56

ethanol/water and the radioactive inorganic phosphate and nucleotides removed from the extract by repeated isotope dilution and precipitation with barium at pH 8·2. The solution was then chromatographed on paper with a mixture of 65 volumes of 95 per cent v/v ethanol/water and 35 volumes of 0·1 M potassium carbonate. Examination of the paper with an automatic radioactivity scanner and with sprays for phosphate and imidazole compounds gave the results shown in Fig. 1. Although the added carnosine phosphates had survived the isolation procedure there was a complete absence of associated radioactivity. The creatine phosphate contained 18,000 c.p.m., so the carnosine phosphates should have had at least 18,000 × 0·019 = 340 c.p.m. However, the radioactivity attributable to the carnosine phosphates was less than 30 c.p.m. A similar absence of carnosine phosphates was found in these muscles contracted at 0° C. under conditions where it had previously been found that net changes in adenosine tri-, di- or mono-phosphates and in creatine and creatine phosphate were either unobservable during a contraction or too small to account for the work done[3,4,6].

These results appear to exclude the possibility that the carnosine phosphates in the Severin, Georgievskaya and Ivanov preparation[2] are phosphate donors in muscle contraction and show that, if present at all, their concentration in muscle must be less than 0·02 µmole per gm.

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Deoxycytidine in Urine as an Indicator of Changes after Irradiation

IONIZING radiation causes obvious changes in the metabolism of deoxyribonucleic acids[1]. An experiment was therefore carried out to determine whether exposure of rats to ionizing radiation causes excretion of catabolites or intermediary products of deoxyribonucleic acids in urine.

Adult white male rats (Wistar strain) weighing 200–320 gm., kept under standard conditions, were used. The animals were irradiated with 76 r./min. at a distance of 40 cm. at 200 kV., 15 m.amp. with a filter consisting of 0·5 mm. of copper and 1 mm. of aluminium. Urine was collected from unrestrained rats kept in glass metabolic cages, making possible the separate collection of urine and stools, and from animals partly restrained in metabolic cages.

Dische's reaction with cysteine and 75 per cent sulphuric acid in Stumpf's modification[2] was applied to an equivalent amount of filtered urine. The spectral character of the colour formed was determined, together with the extinction at the wave-length of maximum absorption. For qualitative evaluation substances isolated from the urine with active charcoal were analysed by paper chromatography and detected using absorption in ultra-violet light and the reaction for deoxyribose and its compounds[3]. R_F values for the substances detected and standards were compared and absorption spectra determined for identification purposes. For quantitative data an equivalent amount of urine analysed chromatographically on Whatman paper No. 3 and substances containing deoxyribose were determined in an aqueous eluate using Dische's reaction[2].

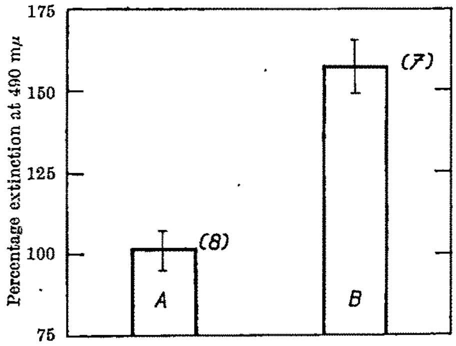

Fig. 1. The effect of irradiation on the excretion of Dische-positive substances in urine. Extinction at the wave-length of maximum absorption (490 mµ) in the urine of A, control rats ; B, irradiated animals. Urine was collected during the first 24 hr. after irradiation with a dose of 300–600 r. and adjusted to a constant volume

In the first experiments a total dose of 300–600 r. was applied. It is evident from Fig. 1 that irradiation causes an increased excretion of substances containing deoxyribose. The colour that arises has a characteristic maximum of absorption at 490 mµ. This increased excretion of substances containing deoxyribose is absent in the urine of animals stressed in other ways (partial restraint, multiple fractures of both hind limbs, injection of formaldehyde into the plantar region of both hind limbs, traumatization in the Noble–Collip drum and burns of the third degree in the lumbar region). This increased excretion of substances containing deoxyribose after irradiation was observed both in animals in metabolic cages fed with normal diet and in those animals that after irradiation had no access to food for the whole period of collection of urine. The excretion of these substances was also found after irradiation of female animals. Further work is required to determine whether there are quantitative differences in the amount excreted between the sexes.

An attempt was made to identify the substances containing deoxyribose that are excreted in increased amount in the urine after irradiation. Using the method described to isolate the substance it was possible to identify it as deoxycytidine on the bases of R_F values, positive reaction for deoxyribose, release of cytosine by acid hydrolysis and spectral characteristics.

It was further necessary to determine the amount of deoxycytidine thus excreted and its relation to the dose of irradiation applied. In addition, the excretion of the deoxyriboside of the other pyrimidine base of deoxyribonucleic acid—thymidine—was also studied.

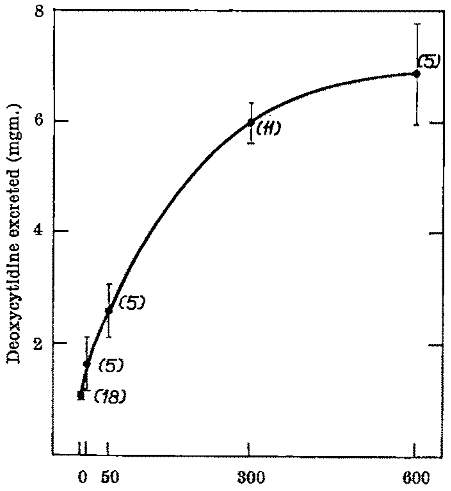

Fig. 2. Relation between the amount of deoxycytidine excreted and the irradiation dose. Urine excreted during 24 hr. was adjusted to a constant volume and an aliquot part analysed by paper chromatography. The part of the chromatogram containing deoxycytidine was eluted and deoxycytidine determined in the eluate colorimetrically (ref. 2). Averages and standard errors are shown

Results are summarized in Fig. 2. It could be shown that within a certain dose-range the intensity of excretion of deoxycytidine depends on the dose of irradiation used during the first 24 hr. after irradiation. On the other hand, it was found that irradiation within a certain dose-range has no analogous effect on the amount of thymidine excreted in the urine during the first 24 hr. after irradiation. Values for the latter substance were on the pre-irradiation level.

Excretion of deoxycytidine after irradiation offers new possibilities in the study of the effect of ionizing radiations on metabolism. From that point of view it is thought to be of importance to attack the problem of the causes for release of deoxycytidine after irradiation. Preliminary experiments showed that this excretion is not due to a renal factor, for in nephrectomized animals irradiation results in accumulation of substances containing deoxyribose in the body. This indicates that irradiation causes either increased release of deoxycytidine from deoxyribonucleic acids or that this substance accumulates as a result of a stop in the synthesis of deoxyribonucleic acid.

It is therefore of interest that a corresponding amount of the other pyrimidine deoxynucleoside, thymidine or its compounds, could not be demonstrated in the urine after irradiation. Consequently, in future work the role of thymidine and its derivatives will be studied together with their metabolic fate in relation to the effects of ionizing irradiation.

Excretion of deoxycytidine in the urine after irradiation also offers a new possibility for determining the degree of damage due to ionizing radiation both quantitatively and qualitatively, since within a certain dose-range the intensity of the reaction depends on the dose. Damage can be detected earlier and much more simply than with the diagnostic methods in use at present. It is of importance that excretion of deoxycytidine could also be demonstrated after low irradiation doses.

It may be expected that the excretion of deoxycytidine can thus become a new sensitive indicator of post-irradiation changes. It may further be useful in evaluation of protection against ionizing radiation.

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Anæsthesia and the Action of DDT on *Anopheles* Larvæ

Between 95 and 100 per cent of newly moulted fourth-stage larvæ of *Anopheles quadrimaculatus* Say (LTD strain, Diptera, Culicidae) die within 24 hr. after a 10-min. exposure to massive doses of suspended DDT (1 : 10,000, 1 per cent acetone)[1]. The purpose of this communication is to direct attention to a very remarkable decrease in mortality of newly moulted larvæ to DDT when they have been anæsthetized with ether or carbon dioxide just prior to testing.

In the first series of experiments, 1-hr. old fourth-stage larvæ of *A. quadrimaculatus* were divided into two groups. Those in the first group were briefly rinsed in distilled water and placed individually in glass stoppered vials containing 5 ml. of 3·75 per cent ether in distilled water where they were left for 10 min. They were removed, washed in distilled water and transferred to freshly prepared acetone suspensions of DDT (10^{-4}) by means of fine cardboard tips. Following exposure to DDT, the larvæ were washed in two 1-l. changes of distilled water and finally placed in small numbered observation beakers containing food and water. The still anæsthetized larvæ were carefully oriented at the air–water interface. The second group was not anæsthetized prior to exposure to DDT. In a subsequent series of experiments larvæ were individually exposed to carbon dioxide gas in a small Erlenmeyer flask for 2 min. prior to treatment with DDT for 5 and 10 min., while controls received no treatment with carbon dioxide.

It is apparent from the results in Table 1 that anæsthesia significantly alters the mortality of larvæ to massive doses of DDT. The differences between ether and carbon dioxide are probably related to the fact that ether gives a deeper and much more prolonged anæsthesia.

The protective effect of anæsthesia is not due to failure of anæsthetized larvæ to eat the DDT drop-

Table 1. Effects of Ether and Carbon Dioxide Anæsthesia on the Mortality of 1-hr. old, Fourth Stage Larvæ of *Anopheles quadrimaculatus* Say to DDT (10^{-4}). Four to Eight Larvæ per Test (Average Five)

Treatment	No. of tests	Percentage dead at 24 hr.
Half-saturated ether for 10 min. before DDT for 10 min.	12	17·9
Controls in DDT 10^{-4} for 10 min.	12	100·0
Carbon dioxide for 2 min. before DDT for 5 min.	5	20·0
Controls in DDT for 5 min.	4	56·3
Carbon dioxide for 2 min. before DDT for 10 min.	5	74·0
Controls in DDT for 10 min.	5	96·0

lets, for DDT affects unanæsthetized larvæ far too rapidly for this to be the case. Nor can it be due to the failure of larvæ to encounter a sufficient number of DDT particles since anæsthetized larvæ which are drawn about within the suspension by cardboard tips are entirely comparable to those left completely quiescent.

The results suggest the intriguing possibility that initially DDT is either actively attached to the cuticle or is actively transported across it. Whatever the final explanation, it is clear that ether anæsthesia, in particular, interferes in some important way with the obtainment of a lethal dose of DDT.

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Fate of Beta-Sitosterol in Housefly Larvæ

TWENTY different species of insect larvæ, distributed among four orders (Orthoptera, Coleoptera, Lepidoptera and Diptera) have been found so far to require sterols as growth factors. All of them, excepting the Dermestidae (*Dermestes vulpinus* Fabr.[1] and *Attagenus piceus* Oliv.[2]), can utilize both zoosterols and phytosterols; certain species, however, grow faster with dietary cholesterol than with a phytosterol[3]. Furthermore, the activity of the intestinal sterol esterase of *Periplaneta americana* L. was found to be limited to the esters of cholesterol, Δ^7-cholestenol and 7-dehydrocholesterol as the substrate[4]. These observations, together with Bergmann's[5] report on the cholesterol content of the phytophagous silkworm *Bombyx mori* L., led us to suspect that the dietary phytosterols are converted to a zoosterol before utilization. Hence, sitosterol conversion was investigated in the larva of the housefly.

Larvæ of *Musca vicina* Macq. were grown to pupation in an axenic culture with *Escherichia coli*, on a mixture of 40 per cent wheat bran and water. The sterols of the culture medium were identified by the isolation of their acetyl derivatives, which, after recrystallization first from 50 per cent ethanol and then ether, melted at 127·5–128·5° C., the melting point of β-sitosteryl acetate. The ultra-violet spectrum and the slow response to the Liebermann–Burchardt reagent proved the absence of conjugated double bonds. Also, the infra-red spectrum was identical with that of β-sitosteryl acetate.

In order to discover whether the sitosterol was transformed by the larvæ to cholesterol, we used the observation of Fraenkel and co-workers[1] that larvæ of *Dermestes vulpinus* Fabr. (*D. maculatus* Deg.) are unable to grow in the presence of plant sterols such as sitosterol, ergosterol and zymosterol, and develop into normal adults only if their food contains either cholesterol or 7-dehydrocholesterol. Our experiments have had the following results:

(1) Newly hatched larvæ of *D. vulpinus* or *D. cadaverinus* Fabr. (*D. ater* Deg.) developed into adults within 26–30 days (temperature 28° C., relative humidity 70 per cent) on ground dried pupæ of *Musca vicina* which had been reared as mentioned previously.

(2) The dermestid larvæ failed to grow and died in their first instar on a diet composed of 78 per cent ground housefly pupæ which had been extracted exhaustively with acetone and chloroform, of 10 per cent dried yeast extract, 11·5 per cent water and 0·5 per cent Nipagin *M*.

(3) Addition of 0·3 per cent cholesterol to this inactive mixture restored the nutritional value it had before the extraction, while neither the addition of the sterol isolated from the diet of housefly larvæ nor authentic β-sitosterol promoted the growth of the larvæ.

(4) The sterol of the housefly pupæ satisfied the sterol requirement of *D. vulpinus* and *D. cadaverinus*; the larvæ developed into normal hide beetles within 30–33 days on the extracted diet, supplemented with 0·3 per cent sterol of fly pupæ.

These results indicate that the larvæ of *M. vicina* convert, at least to some extent, dietary sitosterol into a sterol which is nutritionally equivalent to cholesterol or 7-dehydrocholesterol in *Dermestes* larvæ.

For the sake of comparison, some experiments have been carried out with powders of dried phytophagous insects, namely, pupæ of *Colias hyale* Godt. collected from various kinds of Leguminosae, and larvæ of *Orgyia antiqua* L. picked from their food plant *Polygonium equisetiforme*. Larvæ of *D. vulpinus* were able to complete their life-cycle on powders of both insects within 25–28 days, thus proving that these insects convert the phytosterols of their diet into zoosterols, utilizable by *Dermestes* larvæ.

Recently, Beck and Kapadia[6] have reported that larvæ of *Tribolium confusum* Duv. are capable of converting sitosterol and ergosterol into sterols resembling, or identical with, cholesterol and 7-dehydrocholesterol. While in this case the ingested sterols were metabolized almost completely, apparently only a small percentage of the sitosterol need be converted into cholesterol by the housefly larvæ. Our experiments indicate that the pupæ still contain considerable amounts of the original β-sitosterol.

It follows that the larvæ of *Musca* and *Orgyia* and the pupæ of *Colias* are capable of eliminating the 'supernumerary' carbon atoms of the phytosterol side-chain and convert the phytosterols to the skeleton of cholesterol. The larvæ of *Dermestes* are incapable of carrying out this reaction. This biological degradation is the more interesting as it has recently been shown[7] that the biosynthesis of ergosterol proceeds via cholesterol, into which the additional methyl group is introduced by means of methionine (the same is true for the methylene-branching in the side-chain of eburicoic acid[8]).

Thanks are due to Pest Infestation Laboratories, Slough, Bucks (England), for a supply of pupæ of

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Cytotoxicity of Heterologous Sera to Normal and Leukæmic Human Lymphocytes

THEORETICALLY, cancer therapeutic agents should be able to differentiate between malignant and normal human cells and should be more toxic to the malignant cells. However, human leukæmic lymphocytes and cancer cells did not show, in *in vitro* studies[1,2], any greater sensitivity than normal cells to X-rays and chemotherapeutic agents. These disappointing results led to tests on the capacity of heterologous sera to discriminate between cells.

The slide chamber method[3] was used to determine the survival of normal and leukæmic lymphocytes in a medium composed of equal parts of test sera and of *TC* 199. The term 'leukæmic lymphocytes' is used to designate the lymphocytes from the blood of patients with chronic lymphogenous leukæmia. 'Normal lymphocytes' were derived from the blood or lymph nodes of non-leukæmic patients, most of whom had only minor disabilities. The serum of each rabbit was tested separately within ten days after bleeding. The number of viable lymphocytes were counted 2 hr. after incubation at 37° C. and once a day thereafter. An early positive toxic reaction was defined as one in which 90 per cent of the lymphocytes were killed in 24 hr.

Table 1. TOXICITY OF RABBIT SERA AND OF INACTIVATED GUINEA PIG SERA TO NORMAL AND LEUKÆMIC LYMPHOCYTES

Source of: Sera	Source of: Lymphocytes	No. of tests	Percentage of tests, 10 per cent survival time (days): 0–1	1–3	3–5	5–14
22 Rabbits	15 leukæmic patients	110	46	20	15	19
11 Rabbits	12 non-leukæmic patients	30	3	3	30	63
10 Rabbits	Leukæmic patient 'WOZ'	18	61	28	11	0
8 Rabbits	Leukæmic patient 'SOD'	11	36	0	27	36
Rabbit *B*	13 leukæmic patients	19	84	11	5	0
Rabbit *C*	9 leukæmic patients	10	0	20	40	40
Rabbit *B*	8 non-leukæmic patients	8	13	0	37	50
13 Guinea pigs	11 leukæmic patients	34	0	71	26	3
9 Guinea pigs	9 non-leukæmic patients	25	0	4	48	48
33 Non-leukæmic patients	17 leukæmic patients	36	0	0	0	100
17 Non-leukæmic patients	18 non-leukæmic patients	18	0	0	0	100

The rabbit sera gave early toxic reactions in 46 per cent of 110 tests on lymphocytes from 15 leukæmic patients (Table 1) and in 3 per cent of 30 tests on normal lymphocytes. The median 10 per cent survival time of non-leukæmic lymphocytes was 9·5 days when the cells were in human sera and 5·7 days in rabbit sera. Evidently, the rabbit sera were frequently rapidly toxic to leukæmic lymphocytes but usually had only a delayed toxic effect on normal lymphocytes.

The variability of the results is exemplified in Table 1 by the results on the cells of patients 'WOZ' and 'SOD' and on the sera of rabbits *B* and *C*. The complete data indicated that rabbits differed in the toxicity of their sera to leukæmic lymphocytes, that leukæmic patients differed in the sensitivity of their blood lymphocytes to the toxic sera, and that the sera of some rabbits differentiated between normal and leukæmic lymphocytes in a high percentage of tests.

Observations with an inverted phase microscope indicated that sensitive leukæmic lymphocytes in rabbit sera died by 'fixation', a process similar to that seen in lymphocytes irradiated with 10,000 r.[4]. In contrast, the normal lymphocytes in rabbit sera died by the development of intranuclear vacuoles and pyknosis, which has been studied by cinemicrography[5]. Normal granulocytes and erythrocytes, unlike normal lymphocytes, were sensitive to rabbit sera and lysed within an hour.

Early experiments with guinea pig sera gave the unexpected finding that leukæmic lymphocytes were frequently more sensitive to inactivated (56° C., 30 min.) than to fresh sera. The inactivated guinea pig sera gave a short (1–3 days) 10 per cent survival time in 71 per cent of tests with leukæmic lymphocytes and in only 4 per cent with normal cells.

The present results showed that, on the average, human leukæmic lymphocytes were sensitive to toxic factors in normal rabbit sera and in inactivated guinea pig sera. The rabbit sera usually killed the leukæmic lymphocytes in a few hours by 'fixation' and killed normal lymphocytes in a few days by intranuclear vacuolization. The rabbits differed in the toxicity of their sera and the leukæmic patients varied in the sensitivity of their lymphocytes to the toxic factors.

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Influence of Circulating Adrenocorticotrophin on the Pituitary Adrenocorticotrophic Response to Stress in the Adrenalectomized Rat

REMOVAL of the adrenal glands results in a rise in the level of adrenocorticotrophic hormone in the blood of the rat. Cox and Hodges[1] reported that this increase did not occur until two weeks after adrenalectomy and that, after three to five weeks, there existed a remarkably high concentration of circulating hormone. These results were not inconsistent with the findings of Fortier[2], who showed that adrenalectomy caused a marked increase in the pituitary content of adrenocorticotrophic hormone after a similar time-lapse. It appears that there is an interval of at least two weeks before the rat pituitary gland adapts itself to secrete and maintain this enormously increased output of adrenocorticotrophic hormone in response to the absence of circulating corticoids. Therefore, it was of interest to compare the response to stress in adrenalectomized rats with low blood levels of corticotrophin with that in adrenalectomized animals with high blood levels of the hormone.

Adrenalectomized female Wistar rats were subjected to the stress of ether anæsthesia for 2½ min. at various times after the removal of their adrenal glands. The animals were decapitated, blood was collected from their trunks, injected intravenously into assay rats treated with hydrocortisone and its ability to produce depletion of adrenal ascorbic acid (which is a measure of its adrenocorticotrophic hormone content) determined, as described by Cox, Hodges and Vernikos[3]. The results were compared with those obtained using control adrenalectomized rats which were bled without being subjected to any previous stress. The results are summarized in Table 1.

It may be seen from Table 1 that exposure to ether vapour results in a marked increase in the circulating level of adrenocorticotrophin in the adrenalectomized rat. Furthermore, in contrast to the resting-level, the blood concentration of adrenocorticotrophic hormone after stress is independent of the time-lapse after adrenalectomy. The greatest increases occurred in the rats with the lowest initial levels of the hormone.

These results cannot be explained on the basis that the stores of corticotrophin in the pituitary gland become progressively exhausted after adrenalectomy, since several workers[2,4,5] have shown that removal of the adrenal glands results in a marked increase in the pituitary corticotrophin content. It appears more likely that the secretion of adrenocorticotrophin may be suppressed by a pre-existing high level of the hormone in the blood. The existence of such an 'auto feed-back' mechanism was also suggested by Kitay, Holub and Jailer[6], who found that the administration of exogenous corticotrophin to adrenalectomized rats prevented the usual fall in pituitary corticotrophin induced by stress. Thus, it appears that the circulating level of adrenocorticotrophic hormone may be yet another factor which may influence its release from the adenohypophysis.

Table 1. ADRENAL ASCORBIC ACID DEPLETIONS IN RATS TREATED WITH HYDROCORTISONE AFTER INTRAVENOUS INJECTIONS OF BLOOD FROM STRESSED AND NON-STRESSED ADRENALECTOMIZED RATS (3 ML./100 GM. BODY-WEIGHT)

Adrenal ascorbic acid level in saline-injected controls was 500 ± 10 mgm./100 gm. The figures in brackets indicate the number of animals injected

Time interval after adrenalectomy (days)	Mean ascorbic acid depletion (mgm./100 gm. adrenal tissue ± standard error)	
	Non-stressed	Stressed (ether 2½ min.)
5	−8 ± 13 (6)	126 ± 6 (12)
10	34 ± 8 (6)	146 ± 5 (12)
25	79 ± 8 (42)	139 ± 7 (6)
35	72 ± 12 (6)	155 ± 8 (6)

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Effect of some Lytic Agents on *Aerobacter aerogenes*

IN the course of a study of the surface structures of *Aerobacter aerogenes* the action of lysozyme has been investigated. Preliminary experiments indicated that the enzyme produced no observable changes in the optical density of cell suspensions. In an attempt to promote enzymic attack the conditions were varied by altering the concentration of lysozyme, the time and temperature of incubation, the origin and age of the bacteria, and the *p*H of the suspensions. Cells were also incubated with lysozyme and various concentrations of sodium chloride, magnesium chloride, versene[1] and *tris*-buffer[2]. No lysis which could be attributed to the action of lysozyme was observed under any of these conditions. Microscopic studies showed the appearance, in solutions containing 20 per cent sucrose, of spherical bodies, which were probably similar to the protoplasts obtained by Weibull[3] from *B. megatherium*. These, however, did not constitute more than 1 per cent of the cell population, except in one case, when bacteria incubated overnight with a 2 per cent solution of lipase were subjected to the action of lysozyme in 20 per cent sucrose. About 5 per cent conversion to spheres was observed. In a test for the presence of lysozyme substrate in the cell walls of *Aerobacter aerogenes*, washed cells were suspended in saline at *p*H 3·6 and incubated for 1 hr. at 40° C. with 200 μgm./ml. of lysozyme[4]. The optical densities of the suspensions were measured before and after incubation. The *p*H was adjusted to 10·0 by the addition of sodium hydroxide and the optical density measured immediately. A comparison with the results of a similar experiment in the absence of the enzyme showed that there was some lysis due to lysozyme. The specific substrate is thus present in the cell walls of the organism, but it is doubtful whether the amount available to the enzyme is sufficient to permit extensive lysis.

Lederberg[5] described the preparation of protoplasts from cells of *Escherichia coli* by allowing them to divide

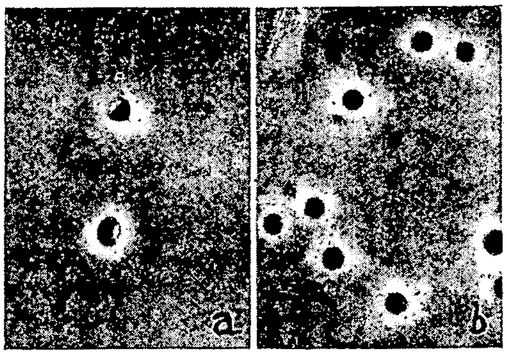

Fig. 1. Spherical bodies of *Aerobacter aerogenes* in 1·0 *M* sucrose (*a*) and in 0·2 *M* sucrose (*b*). (× 1,000)

in the presence of high concentrations of penicillin in a stabilizing medium. It was found that cells of *Aerobacter aerogenes* growing in a simple synthetic medium were lysed by 500 units/ml. of penicillin. However, cell division was suppressed by the high concentrations of sucrose or electrolyte necessary for the survival of any protoplasts formed. The organisms were able to grow and divide normally in 'Lab-lemco' broth containing 20 per cent sucrose. Accordingly, 200 ml. of an overnight broth culture was added to 600 ml. of broth containing sucrose (final concentration 0·6 *M*) and penicillin (1,000 units/ml.). After incubation for 3 hr. at 37° C. with gentle shaking, all the rapidly growing rod-shaped bacteria were converted to spheres. These were fragile to thermal, osmotic and mechanical shock. They could be harvested by centrifugation in the cold and resuspended in solutions of high osmotic pressure, for example, sucrose, glucose, sodium chloride or mixed phosphate buffers. By suspending the spheres in various solutions of sucrose at *p*H 6·8 and determining the concentrations which just prevented lysis at 25° C., their internal osmotic pressure was estimated at 5–6 atmospheres. The osmotic pressure of these bodies, which probably represents the mean osmotic pressure of the cells, is similar to that of *Escherichia coli*[6] and low compared with that of Gram-positive *Staphylococcus aureus* (25–30 atmospheres)[7].

There is some evidence that the spherical transformation undergone by rod-shaped bacteria exposed to the action of penicillin produces bodies the surface of which consists of material which can be differentiated from the cytoplasmic membrane. The spheres can undergo reversible plasmolysis when subjected alternately to high and low (5 atm.) external osmotic pressures in solutions of sucrose or sodium chloride. In concentrated solutions the protoplasm contracts away from the spherical shell surrounding the body. Addition of water causes it to expand until the sphere is filled completely (compare Figs. 1*a* and *b*). Evidently the protoplasmic membrane can become detached from the outermost material. These findings were confirmed by turbidity measurements. They are also in agreement with the observation made by Tomcsik[8], who found traces of cell-wall material on the spherical bodies obtained from *B. anthracis* treated with penicillin. It appears, therefore, that the term 'protoplasts' must be applied cautiously to such spherical bacterial bodies if it implies the complete absence of cell-wall material. Penicillin, while interrupting the biosynthesis of the main part of the cell wall, permits the formation of a fragmentary structure, which is unable to confer rigidity on the bacterial cell.

It is hoped to carry out electrophoretic studies on these bodies in an attempt to characterize their surface. Full details of these and other studies will be reported later.

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Release of Histamine from Mast Cells by Tissue Extracts

IT is now established that the mast cells are an important source of histamine in the body[1]. Histamine can be released from these cells *in vivo* by the injection of certain substances, such as compound 48/80 [2] and distilled water[3], but the mechanism of its release in pathological conditions, such as anaphylaxis and tissue injury, has not yet been satisfactorily explained. This problem has been investigated by exposing isolated mast cells from the rat to tissue extracts. It was found that injured nucleated cells produce a factor which liberates histamine from mast cells with histological changes in the mast cells varying from cellular swelling to cellular disintegration.

The mast-cell suspensions were prepared by injecting 40 ml. of physiological saline solution into the peritoneal cavity of the rat and aspirating the fluid after approximately 30 sec. Cellular elements were concentrated by centrifuging the aspirate. The mast cells were separated by layering the cellular concentrate on top of a 4-cm. column of 50 per cent albumin solution in a Wintrobe hæmatocrit tube and centrifuging the tube at 250*g* for 5 min. The mast cells were recovered from the bottom of the tube and were found to be almost free of other types of cells, which remained above the albumin layer.

Histamine was measured by the colorimetric method of Lowry *et al.*[4]. It was found that histamine was released from these mast cell preparations by mechanical grinding, by the addition of distilled water, and by the addition of compound 48/80 (20 μgm./ml.) protamine (10 μgm./ml.), *d*-tubocurarine (1 mgm./ml.) and peptone (1 mgm./ml.). Approximately 40 mgm. of histamine was obtained per million mast cells.

Histamine was also released from mast cells by saline extracts of spleen, kidney, liver and lung tissue from the rat and the rabbit. Histamine was released by saline extracts of pigeon red cells and of human white cells, but not by extracts of human or rat red cells. The extracts were prepared by grinding the tissue in an equal volume of physiological saline solution and incubating the homogenate at 37° C. for 30 min. Cell debris was removed by centrifugation. The active principle in splenic extract was not destroyed by boiling and was not removed by centrifugation at 28,000*g* for 30 min. It was stable in acid (0·25 *N* perchloric acid for 15 min. at 90° C.) and in alkaline solution (0·3 *N* potassium hydroxide for 24 hr. at 20° C.). Dialysis of the neutralized acid-treated extract against distilled water produced a precipitate which contained the active principle and gave a positive Sakaguchi reaction for arginine, a positive biuret reaction, and a negative reaction for carbohydrate. These findings suggest that the active principle is a long-chain polypeptide containing arginine.

Preliminary (unpublished) experiments have been performed in collaboration with K. Ellem, in which mouse ascites tumour cells and fresh antisera prepared in rabbits against the tumour cells were incubated for 30 min. at 37° C. A substance appeared in the serum which caused disintegration of mast cells with liberation of histamine. When non-immune rabbit serum was substituted for the antiserum, histamine was not released. In association with W. R. Sobey a similar phenomenon was observed with human white cells and fresh anti-human white cell serum prepared in rabbits (unpublished).

These experiments *in vitro* with mast cells suggest that injured nucleated cells produce a factor which leads to the disintegration of mast cells and the release of histamine. The active principle derived from injured cells appears to be an arginine containing polypeptide. The same mechanism may be responsible for the release of histamine when cells are injured *in vivo*.

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Inherited Hypertension in Rats

During the past eight years a colony of hypertensive rats has been developed by breeding from rats with over-average tail blood pressures. The mean blood pressure of the Otago rat colony from which rats were selected for breeding is of the order of 124 mm. mercury for bucks, 116 mm. mercury for does.

We have developed several families with a high incidence of hypertension by selective cross-breeding, and in three strains (*A*, *B* and *C*) by intensive inbreeding, using brother–sister mating. Selective cross-breeding has produced higher pressures than inbreeding (Fig. 1).

Comparison of blood-pressure levels of unanæsthetized rats, gently restrained, and of the same rats under light ether anæsthesia revealed no important difference in the means. The average blood pressures of 70 rats, some hypertensive and some controls, without anæsthesia was 131·9 and under light ether anæsthesia was 129·8 mm. mercury. Direct recording of pressures with a tube in a femoral artery disclosed great variability in the blood pressure of the rat, both under anæsthesia and unanæsthetized. While there is a close relationship between tail pressures and direct pressure readings from a femoral artery, the fluctuations of the blood pressure-level make it necessary to obtain readings on several occasions for each rat in order to obtain an average value.

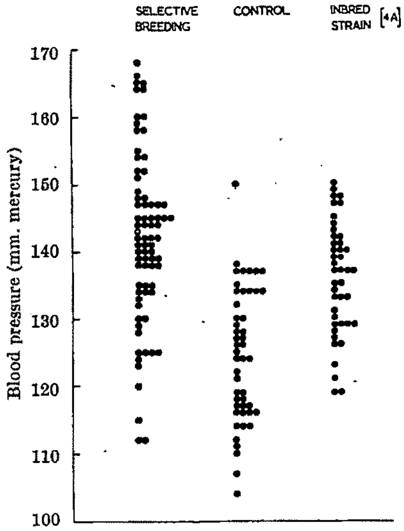

Fig. 1. Blood pressures of rats with inherited hypertension as compared with control rats. Each dot represents the average of several readings in a rat

The general impression is that we can expect at least 30 per cent of buck rats in the Otago hypertensive colony to have tail pressures exceeding 140 mm. mercury. In strains cross-bred selectively we may reasonably expect more than 10 per cent of bucks to have pressures exceeding 150 mm. mercury and occasional bucks to have pressures of 160–170 mm. mercury.

The average pressure of 50 control buck rats measured recently was 124·14 (standard deviation 10·64) mm. mercury; of 43 buck rats of strain *A*, 135·81 (standard deviation 8·20). The difference of the means is about five times the standard error of difference (1·96) and highly significant. The mean blood pressure of 76 selectively cross-bred buck rats was 141·95 (standard deviation 12·53) mm. mercury, which is 17·81 mm. mercury greater than the mean for control rats. The difference of the means is in this case more than eight times the standard error of difference (2·08).

The selectively bred does have a mean pressure of 135·37 and the fourth generation of the *A* inbred strain 129·91, as against 116·33 mm. mercury for the Otago control colony. The differences of the means are in each case more than five times the standard errors of difference and therefore highly significant.

Some results will be published later by Dr. Arthur Veale relating the blood pressure as estimated by the tail method in the rat to the width of cuff, use of ether anæsthetic, absence of an anæsthetic, position of the cuff and recorder on the tail, direct warming of the tail, use of a thermostatically controlled room, etc. We are indebted to Mr. C. Drake, Dr. I. Eryetishir and Mrs. R. Shacklock for some of the blood-pressure readings.

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Influence of the Thymus upon the Reaction of the Rat to Anterior Pituitary Growth Hormone

A relation between the thymus and the growth hormone of the anterior pituitary has been assumed by many authors. It is known that injections of this hormone result in an enlargement of the thymus[1]. A more thorough investigation of the interaction between these two glands seemed of interest.

80 male rats of 130–160 gm. were used. They came from a local inbred strain. The animals were divided into the following groups: (*A*) 20 animals were hypophysectomized by the method of Smith, as described by Farris and Griffith[2]; (*B*) 60 animals were thymectomized by the method of Segaloff[2] and hypophysectomized 8 days later.

Following hypophysectomy, the animals were kept at a constant temperature of 29° C. Growth was recorded for 15 days by daily weighing to the nearest 0·5 gm. The hormone injections were begun the 16th day after hypophysectomy: (*a*) the 20 hypophysectomized animals received daily injections of a commercial growth hormone preparation at daily doses of 0·5, 1·0, 2·0, 3·0 and 4·0 Evans units (4 animals at each dose); (*b*) 20 animals from the thymectomized and hypophysectomized group received the same injections; (*c*) 20 thymectomized and hypophysectomized animals were injected daily with the thymus preparation of Bezssonoff and Comsa[3] at daily doses of 5, 10, 20, 35 and 50 guinea pig units[4] (4 animals at each dose); (*d*) 20 thymectomized and hypophysectomized animals were injected similarly with the same thymus preparation. The thymus injection was followed immediately by an injection of growth hormone at a dose of 2·0 Evans units in all animals. The injections were continued for 15 days with daily weighing.

During the 15 days between hypophysectomy and the first hormone injection, weight loss was constant in all animals. It amounted to about 12 gm. in both groups (1 and 2).

The results during the hormone-injection period are shown in Tables 1 and 2. It can be seen that: (1) in group *A* the growth-rate under the influence of the same dose of growth hormone was significantly smaller than in group *B*. (2) Thymus extract injections alone had no real influence upon the growth-rate of group 2 animals. The loss in weight observed in the preperiod ceased following the thymus injections, but no proper growth was observed. (3) The simultaneous injection of thymus extract and 2·0 Evans units of growth hormone resulted in a significant enhancement of the influence growth hormone upon the growth-rate.

Table 1. Influence of Daily Injections of Anterior Pituitary Growth Hormone upon the Growth-Rate of the Rat

Hormone daily dose (Evans units)	Weight difference after 15 days of daily injections (arithmetical average of three animals)	
	A Hypophysectomized	*B* Thymectomized and hypophysectomized
0 (preperiod)	−12·8 ± 3·0	−12·0 ± 1·0
0·5	0	−4 ± 1·0
1·0	15·0 ± 3·8	6·5 ± 2·2
2·0	30·0 ± 5·1	11·5 ± 2·0
3·0	41·0 ± 7·2	12·0 ± 3·0
4·0	56·0 ± 5·0	17·0 ± 3·0

Table 2. Influence of Daily Injections of Thymus Extract upon the Growth-Rate of Thymectomized and Hypophysectomized Rats

Thymus daily dose (units per rat)	Weight difference after 15 days of daily injections (gm., arithmetical average of three animals)	
	C Injected with thymus only	*D* Injected with thymus and 2·0 units of growth hormone
0	−12·0 ± 1·0	+11·5 ± 2·0
5	−8 ± 0·8	+30·0 ± 4·0
10	0	+45·0 ± 7·0
20	−0·5 ± 0·2	+58·0 ± 6·0
35	−3·0 ± 0·5	+64·0 ± 6·4
50	−1·5 ± 0·6	+80·0 ± 4·8

It can be concluded that the thymus is a significant factor in the growth effect of anterior pituitary growth hormone.

We are indebted to Miss L. Fehres for technical advice, and to Messrs. Choay (Paris) for growth hormone.

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Synapse Discharge by Single Fibre in Mammalian Visual System

Following a single brief electrical shock applied to the optic nerve in the cat there is, from the lowest levels of stimulation, an approximately linear relation between the amplitudes of the pre- and post-synaptic responses recorded in the lateral geniculate body[1]. This was taken to indicate that only a small number of optic tract fibres are needed to discharge a geniculate cell.

In the course of recording extracellularly from single units in the visual pathways of the Dial-anæsthetized cat we have obtained further evidence in favour of this view. In the case of at least two geniculate cells that we have been able to study in some detail we conclude that they were each being discharged by a single optic nerve fibre. The evidence for this is illustrated in Figs. 1 and 2. Records *a* and *b* in Fig. 1 are representative of a large number obtained in the vicinity of a single geniculate cell in response to a stimulus of constant strength applied to the ipsilateral optic nerve; (*a*) consists of three and (*b*) of many superimposed oscillograph traces. It is clear that only three types of response are obtained: (1) a spike potential, (2) a synaptic potential (that is, an excitatory postsynaptic potential[2] recorded extracellularly) and (3) neither of these.

Our evidence that (2) is a synaptic potential is as follows: it always precedes the spike potential as a step on the rising phase; it has the time course of synaptic potentials obtained elsewhere[3]; it sums with a second such potential (Fig 1*e*); it shows progressive depression during a train of evoked responses (Fig. 1*e*), in this respect resembling the end-plate potential at the mammalian neuromuscular junction[4]. Finally, in recording from other single geniculate cells, we have found that *d*-lysergic acid diethylamide (*LSD* 25) abolishes the spike potential, leaving a potential which closely resembles response (2) of Fig. 1. A similar result can also be obtained by placing the test shock in the wake of a brief but rapid train of conditioning stimuli applied to the optic nerve. Fig. 3 shows the effect of a critical blocking dose of *d*-lysergic acid diethylamide, the response prior to the application of the drug being similar to (*b*). During the action of the drug the response varied between the two forms (*a*) and (*b*) of Fig. 3. A further dose of the drug abolished the spike potential and reduced the amplitude of response (*a*) without altering its time course. It has previously been concluded[5] that *d*-lysergic acid diethylamide blocks transmission in the lateral geniculate body by reducing the postsynaptic response to a non-propagating postsynaptic potential.

Our interpretation of the records in Fig. 1 is that the stimulus is critical for a single optic nerve fibre. If the fibre is not excited we obtain response (3), the electrical field response due to other activated fibres and cells; if the optic nerve fibre fires we obtain either response (1) or response (2), that is to say, the synaptic potential is about threshold for the discharge of the geniculate cell. There is no variation in response (2) beyond what is to be expected in the baseline itself under these recording conditions. The spike potential in response (1) arises from the synaptic potential with no detectable increase in amplitude of the latter. If another optic nerve fibre was needed for the cell to discharge then one ought to see an increment in the synaptic potential before the spike arose, and one ought also to see occasionally this second synaptic potential alone; neither was seen.

The spike potential does have another step on its rising phase (in the reproduced photographs clearly visible only in Fig. 1, where it is indicated by arrow). It is unlikely that this step represents a second synaptic potential summing with the first because it is always intermediate between the synaptic potential and the full spike and has a faster rising phase; if it were a synaptic potential one should occasionally see it either alone or initiating the full spike potential of its own accord.

It is not yet known to what degree synaptic activity in different parts of one cell can be recorded by an extracellular electrode. The possibility, therefore, of an unrecorded additional synaptic potential is difficult to exclude. However, in this case, the spike potential was never initiated except after the synaptic potential. This fact excludes the possibility of any other synaptic potential capable of firing the cell, and we feel that it is unlikely that synaptic potentials of any significance have gone unrecorded.

The records in Figs. 1 and 3 were obtained using glass capillary microelectrodes filled with 3 *M* potassium chloride, having a d.c. resistance of about 5 megohms. Those in Fig. 2 were obtained with a fine steel electrode insulated to the tip; records *a*, *b* and *c* are varying responses to a stimulus of constant strength. The remarks made in connexion with Fig. 1 apply also to this cell.

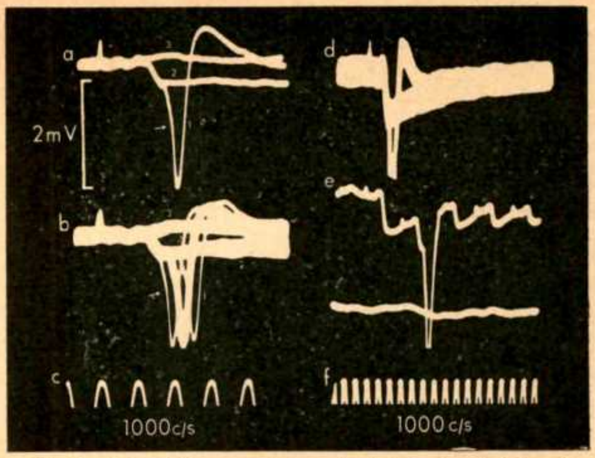

Fig. 1. Extracellular records from single lateral geniculate cell to electrical stimulation of ipsilateral optic nerve. (*a*) and (*b*) Stimulus of constant strength; (*a*) three and (*b*) many successive traces superimposed. Arrow indicates step on rising phase of spike potential. (*d*) Similar series later in the experiment. (*e*) Responses to a train of five stimuli at 300/sec. Time calibration (*c*) applies to (*a*) and (*b*), calibration (*f*) to (*d*) and (*e*). Voltage calibration applies to all records. Negativity upwards in all figures. Spikes truncated in (*d*) and (*e*)

Responses essentially the same as those depicted ing Figs. 1 and 2 have been described by Freygang[6], who also regards response (2) as a synaptic potential. It is not proposed here to enter into the questions of the polarity of the response nor of the exact site of origin of its various components. These have been discussed by Freygang[6].

Our results do not mean that geniculate cells are not also innervated by optic fibres which on their own are incapable of discharging an impulse in the postsynaptic element. We have occasionally observed synaptic potentials which could be graded to some extent by varying the strength of afferent stimulation (cf. Freygang[6]), and the existence of a subliminal fringe around geniculate cells is well established from other studies[7]. These results, however, indicate the existence of 'single-fibre straight-through' pathways in the lateral geniculate nucleus. Although, in the cases described here, the synaptic potential is of critical strength for impulse propagation, certainty would be assured in the unanæsthetized animal and

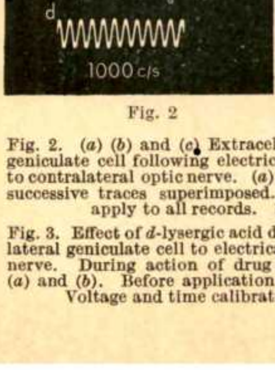

Fig. 2

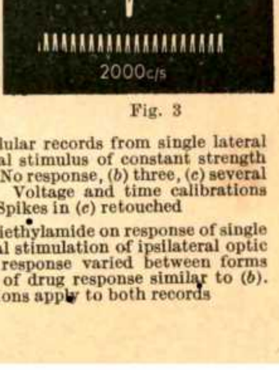

Fig. 3

Fig. 2. (*a*) (*b*) and (*c*) Extracellular records from single lateral geniculate cell following electrical stimulus of constant strength to contralateral optic nerve. (*a*) No response, (*b*) three, (*c*) several successive traces superimposed. Voltage and time calibrations apply to all records. Spikes in (*c*) retouched

Fig. 3. Effect of *d*-lysergic acid diethylamide on response of single lateral geniculate cell to electrical stimulation of ipsilateral optic nerve. During action of drug response varied between forms (*a*) and (*b*). Before application of drug response similar to (*b*). Voltage and time calibrations apply to both records

especially in response to the physiological stimulus of light, since the response in an optic fibre is then likely to consist of a brief high-frequency train of impulses.

This ability of single optic nerve fibres to discharge geniculate cells is almost certainly made possible by the fact that the preterminals branch very extensively[8], so that a single fibre may apply a large number of terminals to a cell. This property of the geniculate synapse is in sharp contrast to the spinal motoneuron, which integrates and acts as the final common path for impulses from a wide variety of afferents. This 'straight-through' property of many geniculate cells by no means excludes the possibility of important modifications in the signal taking place at this level, since changes can occur in the pattern of the repetitive discharge which frequently follows a single afferent volley[9].

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Larval and Adult Hæmoglobins of the Cyclostome *Petromyzon planeri*

SYSTEMATIC investigations of the electrophoretic behaviour of hæmoglobins of various vertebrates have so far been carried out mainly on the higher forms. We have started to investigate the electrophoretic behaviour of hæmoglobin of the cyclostome *Petromyzon planeri* in the adult or in the ammocoetes stage.

Paper electrophoresis did not permit the detection of any consistent differences between adult and larval blood, which by this technique showed the same electrophoretic pattern consisting of a single hæmoglobin band migrating toward the anode. On the other hand, starch-gel electrophoresis provided evidence for the presence of two distinct hæmoglobin bands with different mobility at each stage.

Adult and ammocoetes of *Petromyzon planeri* were collected from the River Sarno near Naples. Blood from 32 adults and 44 ammocoetes has been examined. Blood was collected, by decapitation, in Alsever solution. Erythrocytes were washed repeatedly, and then hæmolysed with distilled water.

Electrophoresis was performed with starch gel using the discontinuous buffer system described by Poulik[1]. Fig. 1 shows the positions of all the hæmoglobin components in the adult and ammocoetes stages. Adult blood has two hæmoglobin bands (I and II). Hæmoglobin I migrates more rapidly and is present in much smaller amounts than II. Larval blood also has two distinct hæmoglobin bands (I′ and II′), which are apparently present in the same concentrations. They migrate more rapidly than the adult ones.

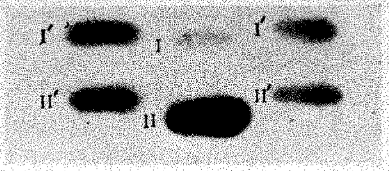

Fig. 1

Apart from the difference in the electrophoretic mobility between adults and larvæ, no other differences were detected among animals of the same stage and in particular no animals with only a single band were found in Nature.

It is conceivable, therefore, that the double-band pattern obtained only by gel electrophoresis might be the result of some kind of degradation of the hæmoglobin molecule due to the supporting medium itself.

Further researches are in progress to clarify this aspect of the problem, bearing in mind what is known for mammalian hæmoglobins[2-4].

Nevertheless we think that the results given above allow the conclusion that in these lower vertebrates the electrophoretic behaviour of hæmoglobin in the larval stage is different from that of the adult stage. Although this may be obviously interpreted as to be due to the presence of some fœtal-like hæmoglobin in the larvæ, it must be noted that unlike the mammalian fœtal hæmoglobin, here the larval hæmoglobin migrates faster than the adult one.

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Respiration and Radiosensitivity of Broad Bean Roots

IN the root-tips of the broad bean, *Vicia faba*, potassium cyanide, hydrogen sulphide and cupferron (the ammonium salt of nitrosophenylhydroxylamine) increase the frequency of chromosome aberrations produced by a given dose of X-rays at very low oxygen pressures[1-3]. In the case of cupferron at least, the effect on radiosensitivity seems to be a result of its inhibitory action on the respiration of bean root tips[3]. The fact that oxygen enhances the radiosensitivity of the root-tip chromosomes of *Vicia faba* has been known since the studies of Thoday and Read[4]. When the roots are respiring normally an oxygen effect does not become evident until the concentration of oxygen in the gas phase exceeds 3 per cent, apparently because at lower concentrations oxygen is removed by respiration in the outer cells of the root, so that completely anaerobic conditions prevail in the central parts. When respiration is inhibited, oxygen is able to diffuse into the cells of the whole meristem, even in cases when the oxygen concentration outside the root is very low. That this is the correct explanation of the increased frequency of aberrations obtained in the presence of cupferron is indicated by the fact that cupferron has no marked influence on radiosensitivity in the complete absence of oxygen[3].

Unlike cyanide and sulphide, cupferron has not been known previously as a respiratory inhibitor. In experiments performed with the aid of the Warburg manometric technique, it has now been found that the respiration of excised bean root tips is markedly inhibited by cupferron. The effect is influenced by the *p*H of the solution and also, to some extent, by the oxygen pressure. A low *p*H and a low oxygen tension favour the inhibitory effect of cupferron. At an oxygen pressure of 2·8 per cent and a *p*H of 5·5, the inhibition produced by 400 μmoles/l. cupferron varies between 70 and 100 per cent. As appears from Table 1, there is a correlation between the effect of cupferron on radiosensitivity and its effect on respiration.

By using cupferron as a respiratory inhibitor, it has been possible to obtain a relation between oxygen pressure and the radiosensitivity of the root-tip chromosomes of *Vicia*, which approaches the true one more closely than that obtained when respiring root-tips are used. This relation is expressed graphically in Fig. 1. As a comparison, the relation between oxygen pressure and effect was also determined in the absence of cupferron and the resulting curve is included in Fig. 1.

Since preliminary X-ray experiments indicated that no further increase of radiosensitivity is obtained by decreasing the *p*H below 5·8 or by increasing the cupferron concentration above 400 μmoles/l., the *p*H was kept between 5·8 and 6·0 in subsequent experiments and the concentration of cupferron was 400 μmoles/l. Oxygen–nitrogen mixtures containing 0·1, 1·0, 2·8, 5·4 and 10·1 per cent oxygen were supplied by the Swedish Gasaccumulator Company. The other oxygen concentrations used in the experiments were obtained by mixing gases with known concentrations of oxygen in appropriate proportions by the aid of flow-meters. Oxygen-free nitrogen was obtained by passing tank nitrogen over active copper in a Meyer–Ronge column[5]. The gases were introduced into the 'Lucite' vessels used for the treatments through fritted glass filters. The beans were kept under anaerobic conditions for 10 min. before an oxygen-free solution of the inhibitor was introduced. The required oxygen–nitrogen mixture was then bubbled through the solution for 25 min. before the irradiation and the bubbling was continued during the irradiation itself. The X-rays were generated in a Müller therapy tube type 71780, operating at 180 kV., 5 m.amp. and filtered by 1 mm. of aluminium. The dose was 100 r. and the dose-rate 20 r./min. The beans were fixed 18 hr. after the irradiation. Permanent Feulgen-squashes were prepared as described previously[6].

It appears from Fig. 1 that, in the presence of cupferron, 1·3 μmoles/l. oxygen is enough to increase the radiosensitivity. The number of isolocus breaks and exchanges obtained per 100 cells under anaerobic conditions is more than doubled at an oxygen concentration of 3·9 μmoles/l., and at 36 μmoles/l. the maximum radiosensitivity seems to have been reached. In the absence of cupferron, no significant increase of radiosensitivity was obtained at oxygen concentrations below 65 μmoles/l. Fig. 1 also shows that the effect is considerably greater in the presence than in the absence of cupferron at high oxygen tensions. The explanation given above for the effect of cupferron on radiosensitivity does not seem to be applicable to the increased effect obtained at high oxygen tensions in the presence of cupferron. The latter may possibly be due to the radiomimetic effect of cupferron[7], although ½-hr. treatments with 400 μmoles/l. cupferron alone as a rule do not produce any chromosome aberrations.

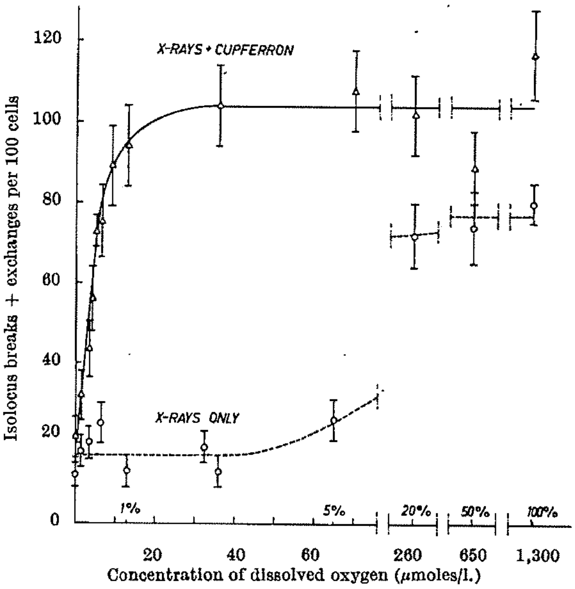

Fig. 1. The relation between the concentration of dissolved oxygen and the frequencies of chromosome aberrations induced by 100 r. of X-rays in the presence and the absence of cupferron

Table 1. THE EFFECT OF 200 μMOLES/L. CUPFERRON ON THE FREQUENCY OF X-RAY-INDUCED CHROMOSOME ABERRATIONS AND ON OXYGEN CONSUMPTION AT *p*H 5·5 AND 7·3

	X-ray experiments				Respiration experiments	
*p*H	Concentration of oxygen in the gas phase (per cent)	Abnormal metaphases (per cent)	Aberrations/100 cells		Concentration of oxygen in the gas phase (per cent)	Inhibition of oxygen consumption (per cent)
			Isolocus breaks	Exchanges		
5·5	1·0	68	52	50	2·8	83
7·3	1·0	22	9	15	2·8	11

The X-ray–cupferron curve in Fig. 1 is very similar to the curve obtained by Howard-Flanders and Alper for the radiosensitivity of the bacterium *Shigella flexneri* at different oxygen tensions[8]. In another series of experiments, the constants *m* ("maximum enhancement ratio") and *K* ("that oxygen concentration which will give $(m + 1)/2$ times the nitrogen radiosensitivity") of Howard-Flanders and Alper[8] were established. The value of *K* obtained in the presence of cupferron at 22° C., 4·2 ± 0·9 μmoles/l., is also very close to that obtained by Howard-Flanders and Alper for *Shig. flexneri*. In the absence of cupferron the value of *K* was found to be about 132 μmoles/l. Thus, when respiration is inhibited, the radiosensitivity of the root-tip chromosomes of *Vicia faba* is affected by a concentration of oxygen which is about thirty times lower than that effective in the absence of the inhibitor.

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Occurrence of an Exotic Oligochaete *Branchiura sowerbyi* Beddard, 1892, in the River Thames

IN the course of a study of the bottom fauna of the River Thames just below Reading, a large population of *Branchiura sowerbyi* has been found among the roots of emergent aquatic plants such as *Carex acutiformis*, *Acorus calamus* and *Schoenoplectus lacustris*. Although samples have been taken from many parts of the River over a stretch of about two miles, all the specimens of *Branchiura* found hitherto have been from a region just below the warm water effluent of Earley power station. The distinctive characters of the worm are its large size compared with other members of the Tubificidae and the possession of filamentous gills on the mid-dorsal and mid-ventral lines of the posterior part of the body.

Branchiura sowerby was first described by Beddard[1], who found it in the mud of the *Victoria regia* tank in the Royal Botanic Society's garden in Regent's Park, London. It was later recorded from similar warm water tanks in Hamburg[2], Dublin[3], Kew and Oxford[4]. According to Stephenson[5], it is common in India, China, Japan and Java, and occurs in the Rhone and elsewhere in southern France, possibly as a result of being introduced with plants imported into gardens on the banks of the rivers. The first person to find *Branchiura* in a natural habitat in Britain was Dr. P. M. Jenkin, of the Zoology Department, University of Bristol. In a recent private communication, she described her findings as follows: "A small colony has persisted for five years on the Kennet and Avon Canal. The species has now appeared for the first time in the Bradford River Avon, at a spot where collections have been made for twenty years. Temperature records stored in the University of Bristol Zoological Department show no indication of warm effluents near either of these sites. The canal is so shallow that it must freeze in the winter. The worms live in organic mud under 4–6 inches of water. They survive well in the laboratory in tubes containing tap water and some mud from their natural environment."

The population of the worms in the Thames is not a small one, as it is estimated from quantitative samples that many thousands are present. They are obviously breeding very freely, and it seems likely that the warm water effluent of the power station (maximum temperature observed, 25° C.) is a more favourable habitat than the unheated waters of the Kennet and Avon Canal. On the other hand, the fact that the worm has appeared in a second unheated habitat suggests that it has become acclimatized sufficiently to be able to increase its numbers in a normal river. That being so, it may well spread through the river and canal system of Britain, and I would be most interested to hear of further records.

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Histochemical Study of the Nasal (Supra-Orbital) Gland of the Duck

THE recent demonstration by Schmidt-Nielsen and co-workers[1,2] that in marine birds the nasal (supraorbital) glands can, under conditions of salt loading, excrete a strongly hypertonic solution of sodium chloride has brought added significance to a study of the comparative cytology and histochemistry of these glands in progress in this department.

In the domestic duck, which has well-developed nasal glands, no histological evidence has been found to support either of the two earlier views on the nature of the secretion of these glands. One widely held opinion has been that the glands elaborate a 'serous' secretion. In the duck gland, cytoplasmic ribonucleic acid, assessed by affinity for toluidine blue and for pyronin, is notably scarce; the secretory elements are, indeed, conspicuously eosinophilic. Moreover, 'zymogen' granules are absent. The other view[3], that the gland produces a slimy (? mucous) secretion, also has no histochemical support. No mucus-secreting elements can be demonstrated by the periodic acid – Schiff technique, or with Alcian blue staining, and there is no metachromatic staining with toluidine blue.

The positive findings of the present study are (1) an extraordinary abundance of mitochondria, which appear almost to fill the cytoplasm of the secretory cells; (2) a moderate content of lipoid which is unstained by sudan III and IV, well stained by sudan black and gives a positive reaction to Baker's acid hæmatein test for phospholipids (pyridine extracted controls give a negative reaction: it seems likely that the phospholipids are mainly mitochondrial); (3) a very abundant blood supply; and (4) moderate amounts of alkaline phosphatase (3 hr. incubation, Gomori technique) in the nuclei, and minimal amounts in the cytoplasm, of cells at the extreme periphery of each gland lobule.

In their eosinophilia and high mitochondrial content, the secretory elements of the nasal gland of the duck are strongly reminiscent of the oxyntic cells of the gastric glands of mammals and of the chloride-excreting cells of the gill of euryhaline fishes, both of which are usually thought to be involved in active secretion of chloride ions.

Preliminary experiments indicate that the nasal glands of the duck are normally inactive, but that under conditions of salt loading they secrete chloride at concentrations of up to 640 m.equiv./litre—a level comparable with that reported for the cormorant[1] and the penguin[2].

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Cytochromes of *Nitrobacter*

A CYTOCHROME system appears to be involved in the oxidation of nitrite by *Nitrobacter* since, at normal temperatures, three cytochrome bands may be seen in suspensions of the cells in the presence of nitrite, but not in its absence. These are two sharp bands at 521 $m\mu$ and at 550 $m\mu$ and a more diffuse, less-intense band at about 589 $m\mu$ [1].

We have now obtained further indications of involvement of cytochromes in nitrite oxidation since the oxidation has been found to be inhibited by carbon monoxide and by cyanide. We have therefore carried out a more detailed examination of the cytochromes of *Nitrobacter*.

In the presence of aqueous glycerol (50 per cent v/v), at the temperature of liquid air[2], the band at 589 mμ was resolved into two separate bands at 598 mμ and at 580 mμ. The former band probably represents that of the cytochrome *a* component of the cells.

In order to determine the distribution of the cytochromes *Nitrobacter* cells were crushed in the Hughes press and whole cells removed by centrifugation at 4,000*g*. The cell-free suspension thus obtained was separated into an insoluble fraction and a cell extract by centrifugation at 15,000*g*. The insoluble fraction, with dithionite, showed all the bands present in the whole cells, whereas the extract contained only the cytochrome with bands at 521 mμ and 550 mμ.

When the cells were disintegrated with the Nickle shaker and fractionated by the method of Salton and Horne[3], a preparation was obtained which, by electron microscopy, was shown to consist of cell walls. The preparation was deep red in colour and appeared to contain all the cytochromes present in the whole cells; the extract of the cells, however, as in the case of the extract of cells crushed in the Hughes press, contained only the cytochrome with bands at 521 mμ and 550 mμ.

One of the cytochromes present in the insoluble fraction of the cells crushed in the Hughes press appears to have cytochrome oxidase activity. The soluble cytochrome of *Nitrobacter* is not autoxidizable, but addition of a suspension of the insoluble fraction to the cell extract renders this cytochrome oxidizable by air; the insoluble fraction also catalyses the oxidation of reduced mammalian cytochrome *c* by air. Cytochrome oxidase activity in the insoluble fraction could also be demonstrated manometrically with ascorbate[4]; the uptake of oxygen by this fraction in the presence of ascorbate was increased by the addition of either the soluble fraction of the cells or by mammalian cytochrome *c*. This observation indicates that the insoluble fraction is relatively deficient in *c*-type cytochromes (probably the cytochrome with bands at 521 mμ and 550 mμ) and that the cytochrome oxidase of the insoluble fraction is capable of coupling with mammalian cytochrome *c*.

The similarity between the 550 mμ cytochrome and mammalian cytochrome *c* was further demonstrated by examination of an extract from crushed cells partially purified by ethanol fractionation at 0° C.

The spectrum of the cytochrome was found[5] to be similar to that of mammalian cytochrome *c*, with the main bands in the reduced form at 550 mμ, 521 mμ and 416 mμ. The spectrum of the reduced pyridine hæmochromogen of the cytochrome was identical with that of mammalian cytochrome *c*.

The E'_0 of the cytochrome was determined by titration with ferrocyanide in the presence of ferricyanide in an atmosphere of nitrogen. It was found to be in the region of 0·25 V. at *p*H 7·5 and 25° C. The reduction of the cytochrome appeared to involve a single electron transfer since the slope of the graph of log ferrocyanide/ferricyanide against log reduced cytochrome/oxidized cytochrome was 45° C.

The isoelectric point of the cytochrome, determined by electrophoresis on paper with glucose as a marker to correct for electro-endosmosis, was found to be approximately 6·5. In this respect the *Nitrobacter* cytochrome appears to differ from mammalian cytochrome *c*, which has an isoelectric point[6] of 10·65.

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Occurrence of Gentisic Acid in Plant Tissues

In the course of chromatographic studies on the phenolic constituents of *Theobroma cacao* L., an ultra-violet fluorescent compound (compound *A*), possessing an R_F value of 0·28 in benzene/acetic acid/water, was shown to be widely distributed throughout the tissues of the plant[1]. This compound has now been shown to possess chromatographic and ultra-violet fluorescence properties identical with those of gentisic acid (2 : 5 dihydroxy benzoic acid). Chromatographic examination of a large number of leaf hydrolysates has revealed that gentisic acid is widely distributed in the plant kingdom, and it would appear to be one of the most commonly occurring aromatic acids of plant tissue. This acid, although usually present in very small or trace quantities, can readily be detected by the chromatographic technique described. The presence of other fluorescent aromatic acids, namely, caffeic, ferulic and sinapic acids in leaf hydrolysates has recently been reported[2].

Although a good separation of compound *A* from the other fluorescent constituents of cacao leaf hydrolysates is effected by the use of the benzene/acetic acid/water system[3], the use of 20 per cent aqueous potassium chloride; *iso*propyl alcohol/ammonia/water[4] or chloroform/acetic acid/water[5] is rendered difficult by the fact that certain flavonoid and phenolic residues present in cacao extracts tend to conceal the gentisic acid spot. A preliminary separation was therefore carried out, the ethereal extract of the hydrolysate, prepared by the standard procedure[1] being applied to the chromatogram in a continuous band. After development with benzene/acetic acid/water the appropriate fluorescent band was cut out and eluted with hot methanol. The methanolic extract thus obtained was run against an authentic standard of gentisic acid (Delta Chemical Works, Inc.) in each of the four solvent systems shown in Table 1. In all cases the R_F values of compound *A* were identical with those of gentisic acid. The fluorescence of compound *A* was also observed to be identical with that of gentisic acid, namely, a bright blue, which turned green-white on exposure to ammonia fumes. It was noted that in both cases the greening with ammonia was of a much more transient character than is observed with the chlorogenic acids, the colour reverting to the

Table 1. CHROMATOGRAPHIC COMPARISON OF GENTISIC ACID AND COMPOUND *A* ISOLATED FROM LEAF TISSUE OF *T. cacao* L.

	Gentisic acid *RF*	Compound *A* *RF*
Benzene/acetic acid/water (60 : 70 : 30)	0·28	0·28
20 per cent aqueous potassium chloride	0·55	0·55
*iso*Propyl alcohol/ammonia/water (8 : 1 : 1)	0·71	0·71
Chloroform/acetic acid/water (2 : 1 : 1)	0·30	0·30

original bright blue immediately on removal from the ammonia.

Further confirmation of the identity of compound *A* with gentisic acid was obtained by spraying the chromatogram with an aqueous solution of ammonia (specific gravity 0·910) and immediately examining in ultra-violet light. Under these conditions the gentisic acid spot and that of compound *A* showed a characteristic yellow fluorescence. This change in the colour of the fluorescence from blue to yellow after spraying with ammonia was found to be highly specific for gentisic acid.

The procedure adopted for the routine screening of leaf tissue for gentisic acid was as follows: 2 gm. of fresh, finely shredded leaf tissue were digested with 10 ml. of 20 per cent aqueous hydrochloric acid (v/v) for 20 min. on a boiling water bath. After cooling and filtering, the filtrate was extracted with 2 ml. of diethyl ether and 0·1 ml. of this was applied with a micropipette to Whatman No. 4 chromatography paper, which was formed into a cylinder and developed with benzene/acetic acid/water[3]. The dried chromatograms were then examined in ultra-violet light and the gentisic acid spots located by their blue fluorescence. Confirmation of their identity was obtained by the use of the ammonia spray. Identification was in all cases effected by the use of a marker of authentic gentisic acid.

Representative species of 80 families of Angiosperms were examined by these methods, and positive identifications of gentisic acid were obtained in 73 families. No free gentisic acid was detected in neutral plant extracts; preliminary hydrolysis is essential for the release of the acid from the complex in which it occurs. Studies are in progress on the nature of this complex in tissues of *T. cacao*.

Although gentisic acid was of more frequent occurrence in leaf tissue than caffeic acid, the latter compound is usually present in larger amounts. No correlation was observed between the distribution patterns of gentisic acid and those of other fluorescent phenolic constituents of the leaf extracts.

Although gentisic acid is found in both herbaceous plants and trees, it was notable that in the families included by Hutchinson[6] in the Lignosae, gentisic acid was of more frequent occurrence and tended to be present in larger amounts than was observed in the Herbacae and Monocotylae. It is therefore believed that gentisic acid may be concerned in lignification or in some process associated with it. A similar association has been observed by Bate-Smith in relation to the distribution of leucocyanidins in leaves[7]. Some correlation was also apparent within a family, between the degree of lignification of the genus and the content of gentisic acid present. The relation of gentisic acid to lignification will be discussed in a paper to be published elsewhere.

The widespread occurrence of gentisic acid in plants is also of interest from the point of view of host–parasite relations, since a number of phenolic acids, including protocatechuic acid (3 : 4 dihydroxybenzoic acid), have been shown to confer disease resistance upon certain species of plants. That the content of bound gentisic acid in the surface tissues of the plant may be a factor in the resistance of the plant to fungal attack is, moreover, supported by the observations of Klöpping and van der Kerk[8], who showed that a derivative of gentisic acid from *Populus candicans* possesses highly fungicidal properties *in vitro*.

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Rhizobium Needs Magnesium, not Calcium

IN tropical countries there occur abundant examples of legumes that are normally nodulated despite the fact that they grow on acid soils, low in calcium. Observations of some particularly striking examples of this behaviour in the poor 'Wallum' soils of south-east Queensland led to a re-examination of the symbiotic system in the legumes[1]. It was postulated that the tropical legume equipped with cowpea-type *Rhizobium* is adapted to these low-calcium environments because they were the conditions under which the symbiosis evolved, while the clovers and clover type *Rhizobium* are specialized types that have developed calcicole habits. Growth experiments with the bacteria using clays saturated to varying degrees with calcium using McCalla's technique[2] appeared to support the hypothesis, in that strains known to require lime, such as those from lucerne, gave growth in proportion to the degree of calcium saturation of the clay, whereas cowpea-type strains showed relative indifference to the calcium-level. A basic study of the relative calcium requirements of these types was then begun, using a liquid medium in which calcium was supplied in solution, not absorbed on a clay.

To do this a new medium had to be devised. The standard growth medium for *Rhizobium* includes yeast extract which simultaneously supplies nitrogen, growth-factors and minerals, including a significant quantity of calcium. Before a study of calcium requirement could be made it was necessary to prepare a basal medium entirely free from calcium by eliminating yeast extract.

The medium used was constituted as follows:

Disodium hydrogen phosphate	0·45 gm.
Magnesium sulphate	0·1 gm.
Potassium nitrate	0·6 gm.
Ferric chloride	0·01 gm.
Mannitol	10·0 gm.
Thiamin	100 μgm.
Biotin	0·5 μgm.
Distilled water	1,000 gm.

Each ingredient was freed of calcium and all glassware was scrupulously washed with acid. No calcium could be detected by complexometric analysis of the complete medium. The pH of the medium after autoclaving was 7·5 and when 0·02 per cent calcium chloride was added, 6·9.

In this medium 48 strains of *Rhizobium* selected to cover a cross-section of Leguminosae were serially cultured at approximately 14-day intervals for ten generations in comparison with the same medium containing calcium at the normal rate (0·02 per cent calcium chloride). Growth was made in screw-cap tubes containing 10 ml. of medium that was not shaken. All strains made some growth that varied from a trace to 6×10^8/ml. In many cases growth in the series lacking calcium was noticeably superior to that in the parallel series with calcium added. To eliminate the possibility of calcium being obtained from the glass of the culture tubes, transfer of six strains, representing pea, clover, lucerne, cowpea, cassia and acacia, was made from the seventh generation to silica vessels. Serial passage in these vessels to the sixteenth generation was made without loss of vigour.

Mutation, accompanied frequently by loss of infectivity, was high in this medium, but it occurred equally in the series free of calcium and that to which calcium was added.

This experiment showed clearly that *Rhizobium*, whether of clover or cowpea-type, required no calcium for growth. Nevertheless, there remains to be explained the repeated observation that the application of lime to certain soils in which *Rhizobium* will not multiply renders them suitable for growth. One such soil, a krasnozem, was described by Vincent and Waters[3] from Pearce's Creek, near Lismore, New South Wales. Some of this soil was obtained and it was confirmed that, following autoclaving, no multiplication of clover *Rhizobium* was possible in it, but after the addition of calcium hydroxide equivalent to a dressing of 6 tons/acre of lime, populations of $3–5 \times 10^8$/gm. were achieved in seven days. The pH of this soil following autoclaving is approximately 5·0 and it could be argued that the application of lime produced bacterial growth either by eliminating acidity or by supplying needed divalent calcium ions. However, when acidity was eliminated by the hydroxides of sodium, potassium and ammonium, no growth occurred. Furthermore, when equivalent quantities of hydroxides of magnesium or barium were applied, they were as effective as calcium in promoting growth. This eliminated Ca^{2+} as the essential factor but pointed to the need for a divalent cation.

From this point a return was made to the synthetic medium which contained magnesium as its only divalent cation. By several simple experiments it was possible to prove that magnesium was the essential element needed by *Rhizobium.* If the magnesium sulphate in the medium was replaced by sodium sulphate no growth occurred. The addition of calcium, strontium or barium had no effect, but the addition of magnesium resulted in immediate growth.

Apparent growth responses to added calcium on soil or clay are explicable by the position occupied by Mg^{2+} in the lyotropic series. Additions of sodium, potassium or ammonium ions will produce no response since these do not displace magnesium. Additions of divalent calcium or barium ions produce growth response because they displace and render available Mg^{2+} for the bacteria.

Following repeated observations during these experiments that added calcium appeared to be actually inhibitory, presumably by antagonizing the uptake of magnesium, the results were applied immediately to the improvement of growth in agar culture medium, which traditionally contains large additions of calcium carbonate or chloride. By eliminating added calcium compounds and strongly augmenting the amount of magnesium sulphate added, considerable improvement of growth of slow-growing types was obtained.

A full account of these experiments will be published elsewhere.

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Field Observations of Midday Closure of Stomata in the Oil Palm, *Elaeis guineensis* Jacq.

During the course of studies on stomatal movement of oil palms under field conditions, some effects of soil moisture on midday closure have been observed. These are of particular interest when examined in the light of the hypothesis of Heath and Orchard[1] on the relationship between leaf temperature and midday stomatal closure.

The technique used was a modification of the infiltration method of Molisch[2], employing a series of *iso*propanol–water mixtures. The results are in good agreement with actual measurements using material fixed by Lloyd's method. All the palms examined were in an area of approximately ¼ acre; they were three years old at the start of this work. Each observation consisted of readings carried out on leaflets from the tip, mid and base of each of six leaves, three on the north and three on the south side of one palm. Each set of three leaves comprised a young, middle-aged and an older, but not senescent, leaf.

Preliminary work in 1956 indicated that midday closure occurred during the latter half of the dry season, which normally extends, with very little or no rain, from November to April, but disappeared with the onset of the rains. During the same period in 1957, midday closure was followed daily. After any appreciable rain, stomatal closure became less severe and remained slight or non-existent until the effect of the rain wore off, and a return to the former state occurred. The extent of closure was correlated with total daily evaporation as measured by a raised tank evaporimeter; after rain a relationship still appeared despite the reduced closure.

To obtain further information on the effect of rain, a comparison was made during the severe dry season of 1958 of the extent of midday closure in two palms, one of which was amply watered. After 33 days the second palm was also watered to show any differences not due to treatment. Air temperature was measured at each observation time

Table 1. THE EFFECT OF WATERING ON MIDDAY CLOSURE OF STOMATA IN THE OIL PALM. PALM 1 WAS WATERED THROUGHOUT AND PALM 2 DURING THE SECOND PERIOD ONLY. THE UNITS OF STOMATAL APERTURE ARE ARBITRARY, SEE FIG. 1

	Period 1		Period 2	
	Difference in		Difference in	
	aperture	temperature	aperture	temperature
Palm 2 (unwatered)	3·39	1·50	—	—
Palm 1 (watered)	±0·14	±0·15	0·03	0·10
Palm 2 (watered)	—	—	±0·07	±0·48

by means of a thermometer 75 cm. above ground-level in the shade of the palm. All the readings were taken between 13h. and 13.30h. local apparent time.

The results are presented in Table 1. There is a significant difference between the extent of midday closure in the two palms which disappears when the second palm is watered. The significant difference in air temperature under the two palms also disappears after watering. Each point in Fig. 1 is a mean of eighteen readings on a single palm plotted against the mean temperature under the palm during the observational period. A difference of 3° C. between the air temperature – leaf temperature relationship for the two treatments would account for the observed differences between the watered and unwatered palms. A significant reduction in the temperature of fully exposed leaflets due to watering was demonstrated, but the instrument used was broken before calibration.

Heath and Orchard propose that midday closure of stomata is a temperature effect operating through the carbon dioxide concentration in the intercellular space. The results presented here confirm their observations on onion and coffee, especially as stomatal closure in the range 30–35° C. is so marked. No leaf temperatures are known, but the effect of watering in reducing air temperature is very clear. The observed lag period between watering and the resulting drop in air temperature indicates that the latter is not due to evaporation at soil-level. Although increasing leaf temperature may cause stomatal closure, it is clear that midday closure of stomata may also be influenced by water strain, whether this operates directly on aperture, with a consequent temperature change due to altered transpiration, or whether, as seems likely in view of Heath and Orchard's work, transpiration affects leaf temperature, which determines stomatal aperture. There would appear to be some justification for regarding midday closure of stomata as a sensitive indication of water stress[3,4].

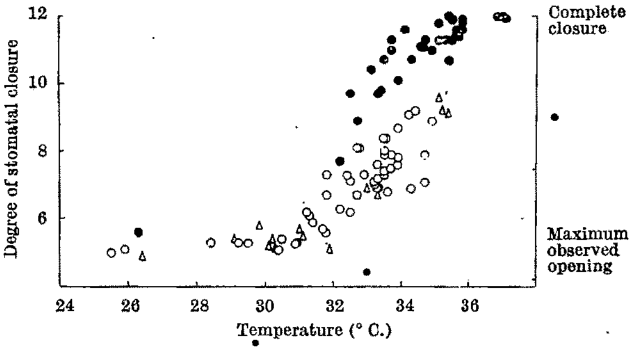

Fig. 1. Extent of midday stomatal closure in watered and unwatered palms plotted against air temperature under the palms. ●, Palm 2 unwatered; ○, palm 1 watered; △, palm 2 watered

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Light Microscopic and Electron Microscopic Observations on the Dividing Walls of Cells in *Chara* spp.

IN the simple as well as in the higher plants (Thallophyta and Cornophyta) the structure of cell walls exhibits a great variety of characteristics of partly microscopic, partly submicroscopic order of magnitude. These structural peculiarities, which may be characteristic of wider relationships or even of species, are closely connected with the particular functions of the cell. By our investigations, carried out on the cell walls of the genus and species *Chara*, for example, *Chara foetida* A. Br., *Ch. contraria* A. Br., *Ch. hispida* L., *Tolypellopsis stelligera* Mig., *Nitella* sp., *Tolypella intricata* (Trentep.) or Leonhardi, light was cast upon the connexion existing between structure and function.

All material was first treated with dilute hydrochloric acid, and, after thorough washing, with tri-ethanolamine[1], making the dividing walls easily accessible, since the treatment causes the cells to fall apart. Both bulging end-walls of the large internodes were then severed, cut into small pieces and placed on a collodion film. Preparations were shadowed with palladium at a shadowing angle of 15–35°.

In all species examined the end walls of the internodial cells were found to be perforated (Fig. 1). The pores do not arrange themselves regularly; a peculiar system in which mostly two, sometimes three, structural units of different orders of size are desirable (Fig. 2). The largest structural units on the bulging end-wall seem to be regular, polygonal areas produced by the walls of the adhering smaller nodial cells which are in contact. These areas are visible even under the ordinary stereo microscope. We believe these big polygonal areas to be pore fields as they are perforated all over. The distribution of the perforations, however, is irregular; they occur in larger and smaller aggregations, thus forming secondary structural units. These are surrounded in the pore fields by islets consisting of a dense network of cellulose microfibrils. The islets are interconnected by extensions and thus form a lattice delimiting smaller or larger spaces in which a pore cluster is usually contained, the mesh of microfibrils being densely perforated. Less frequently, the lattice encloses regular, triangular or quadrangular spaces and exhibits thinner strands running diagonally, formed by still smaller pore clusters aggregated within the larger ones and thus representing structural units of the third grade (Fig. 2).

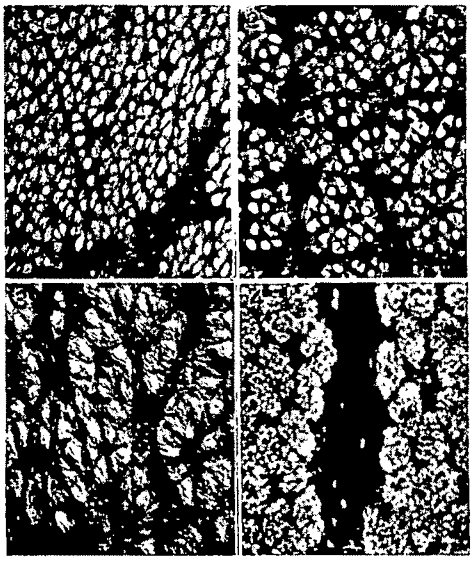

Fig. 1. Detail from the end-wall of the axial internode of *Chara contraria*. (Electron micrograph, × 3,400)

Fig. 2. Pore clusters in the end-wall of the axial internode of *Chara contraria*. (Electron micrograph, × 4,000)

Fig. 3. Detail from the end-wall of the axial internode of *Chara hispida*. (Electron micrograph, × 4,000)

Fig. 4. Detail from the end-wall of the axial internode of *Chara contraria* in the phase contrast microscope. (× 750)

The average diameter of the pores is 400 mμ, their shape is a more or less distorted circle, surrounded by a densely woven texture of cellulose microfibrils. At times the opposite apertures of the pores do not coincide, the pores presumably being oblique. The various species show differences as to the form, dimensions and arrangement of the pores (Fig. 3).

The islets and the perforations mentioned above being within the range of the light microscope, their microscopic examination was also undertaken. Under the phase-contrast microscope not only the network surrounding the pore clusters but also the larger pores themselves were easily observable (Fig. 4).

With the help of easily recognizable islets, identical spots could sometimes be photographed in the light microscope and in the electron microscope. It was proved by further examinations that the walls communicating with the end-wall of the axial internode of the smaller nodial cells, as well as the contiguous walls of the internodial and nodial cortex cells were also perforated. The side-walls of the axial internode and of the internodial cortex cells, however, do not have a similar porous structure[2].

It may be assumed with certainty that the pores in question are the crossing points of the cytoplasmic threads connecting the contiguous cells, the so-called plasmodesmata. These are responsible for the unity in the physiological functioning of the alga and are analogous to the porous structure recognized in the cell wall, more precisely in the pits of the cell wall of higher plants[3-6]. It is due probably to the extraordinary size of the cells that the pores of various *Chara* sp. have dimensions well within the range of the light microscope. The pore fields are of the order of mm.[2] and the network probably serves to strengthen the comparatively large, but exceedingly thin, porous membrane.

Full details of this work will be published in the near future. We wish to thank Mrs. T. Tóth for the excellent technical help she has given.

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Effect of Storage Conditions on the Incidence of *Gloeosporium* Rots of Apple Fruits

SAMPLES of Cox's Orange Pippin obtained from various parts of south-east England were held in cold (37° F.) and in gas (39° F., 3 per cent oxygen and 5 per cent carbon dioxide) storage for periods of approximately 3½ months and 4½ months respectively. On removal from storage, the samples were examined for rots caused by *Gloeosporium* spp., but owing to lack of time the causal species on each rot was not identified. It was noted during 1955–56 and 1957–58 and, to less marked extent, in 1956–57 also, that in certain samples the percentage of apples recorded as damaged by these rots was less after gas storage than after cold storage, despite the higher temperature and longer period of storage, whereas with other samples the converse occurred.

A preliminary examination of seventeen samples after gas storage in 1957–58 indicated that the different behaviour of samples in this respect might be caused by a difference in the predominating species of *Gloeosporium*. Larger sub-samples, of up to 25 apples, were therefore taken from four samples that showed decreased rotting in gas store and from four that showed increased rotting, each sample being from a distinct orchard. The fungus causing each rot was identified by its spores, apples with non-sporing rots being kept at room temperature in polyethylene bags until as many of the rots as possible had been identified. The results are presented in Table 1.

G. album usually develops in storage more slowly than *G. perennans*, and this might make it more susceptible to the concentrations of carbon dioxide and oxygen reached some days after the store is

Table 1. ROTTING OF SAMPLES IN COLD AND IN GAS STORE, IN RELATION TO PERCENTAGE OF ROTS DUE TO *Gloeosporium album*

Origin of sample	Percentage of apples infected with *Gloeosporium* spp. Cold store	Gas store	No. of rots due to: *G. perennans*	*G. album*	Percentage of rots due to *G. album*
Eynsford	76	35	25	49	64
East Malling	34	9	4	26	87
Norwich	24	17	5	10	67
Beccles	57	23	4	94	96
Chelmsford	8	16	18	3	14
Canterbury	27	41	84	4	5
Burlingham	29	48	98	7	7
Marden	12	32	70	—	—

closed. Alternatively, its late development in store may be linked with an advanced stage of maturity of the apple and therefore make it more likely to be affected by a treatment such as gas storage that delays maturity.

Quite apart from the potential economic value of this finding, if confirmed, the results suggest that there are important differences in the biology and mode of parasitism of these two species of *Gloeosporium*.

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Terpene Formation in Pine from Mevalonic Acid

Recent studies have demonstrated that mevalonic acid is a key intermediate in the biosynthesis of animal sterols[1]. Studies of the origin of triterpenes and carotenoids in soya bean and fungi indicate that these compounds may also be formed from acetate through mevalonic acid[2]. Although the incorporation of atmospheric carbon dioxide into pine terpenes has been demonstrated[3], studies on the nature of the pathway by which these compounds originate have not been reported. In the present work, seedlings of *Pinus attenuata* were found to incorporate acetate-2-^{14}C and mevalonic acid-2-^{14}C into the monoterpenes. The turpentine of this pine is 98 per cent α-pinene[4].

Shoot tips were cut from actively growing 2-year-old seedlings of *P. attenuata*. These shoot tips (about 3 gm.) were placed in cone-shaped vials containing 1 ml. of the radioactive substrate in 0·01 *M* potassium phosphate buffer, *p*H 5·9. The vials, with the base of the shoot tips immersed, were sealed with 'Parafilm' wax paper to prevent evaporation. The tops were then exposed to a 100-watt incandescent lamp and air was blown across them to induce rapid transpiration and uptake of the substrate. Sufficient water was added to the vials to keep the stem bases submerged during the 8 hr. they were allowed to metabolize the absorbed solutions. On removal the shoots were frozen in liquid nitrogen, wrapped in aluminium foil and stored at −10° C. until extracted. Extraction was by homogenization in ethyl ether with mortar, pestle and sand. The samples were extracted until radioactivity was absent from the ether extract. Finally, the homogenized tissue was shaken in a closed Erlenmeyer flask on a mechanical shaker for 3 hr. with four changes of ether. This ether was combined with the earlier extract and the combined volume (about 200 ml.) was reduced to 20 ml. by distillation at 38° C. This concentrate was passed through a column (70 mm. high, 15 mm. diameter) packed with basic alumina oxide (Woelm) and 'Darco' decolorizing charcoal. The column was washed with approximately 100 ml. of ether yielding a colourless eluant containing a minimum of acid residue. The ether eluant was concentrated by distillation to 0·5 ml. and pure α-pinene (0·2 ml.) was added to the ether concentrate. The α-pinene was then separated from a portion of this mixture by gas-liquid-partition chromatography with helium as the mobile phase and 'Carbowax' 1540 on diatomaceous earth as the stationary phase. The α-pinene, fraction *A*, was collected at 120° C. (Fig. 1). The column temperature was then increased to 190° C. while helium was permitted to flow through for 30 min. to flush the column. Fraction *A* was then resubjected to chromatography at 120° C. and fraction *B* isolated. Fraction *B* was again chromatographed and separated into two fractions, *C* and *D*. The infra-red spectra of the material isolated in fractions *B*, *C* and *D* were identical with that of pure α-pinene; the specific activities of the pinene in each of these fractions was found to be constant (Fig. 1).

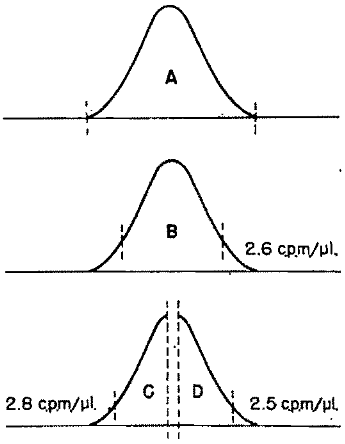

Fig. 1. Specific activity in carbon-14 of α-pinene fractions characterized by gas chromatography. α-Pinene was extracted in ethyl ether from shoot tips of *Pinus attenuata* incubated for 8 hr. with $8{\cdot}8 \times 10^6$ c.p.m. mevalonic acid-2-^{14}C. Counted by liquid scintillation in 0·5 per cent 2,5-diphenyloxazole in toluene (ref. 6). Specific activity expressed as c.p.m./µl. of α-pinene

The nitrosochloride was then prepared from another portion of the final ether extract containing carrier α-pinene. The specific activities present in the crystals isolated after three and four recrystallizations are given in Table 1. From this evidence we may conclude that the carbon-14 derived from mevalonic acid is incorporated into α-pinene in pine. Complete details of this study will be published elsewhere.

The amount of radioactivity recovered in the α-pinene of the shoot rips was approximately 0·02 per cent after 8 hr. incubation. When slices of *P. attenuata* were incubated for 2 hr. with mevalonic acid-2-^{14}C, 0·5 per cent of the activity was recovered in α-pinene. In similar experiments with acetate-2-^{14}C, approximately 0·01 per cent was incorporated in the α-pinene fraction of whole shoot tips. However, acetate can be metabolized many ways in pine tissues[5]. It would therefore be erroneous to conclude from these preliminary studies with intact tissues that mevalonic acid is incorporated in preference to acetate.

I wish to thank Drs. N. T. Mirov, P. K. Stumpf and R. Lemmon of the University of California, Berkeley, for the use of laboratory facilities and for constant encouragement in these studies; appreciation is also expressed to the Fundamental Research Group at Merck and Co., Rahway, New Jersey, for

Table 1. Specific Activity in Carbon-14 of α-Pinene Nitrosochloride.

Nitrosochloride of α-pinene formed from concentrated ethyl ether extract of shoot tips of *Pinus attenuata* incubated for 8 hr. with mevalonic $8{\cdot}8 \times 10^6$ c.p.m. acid-2-^{14}C. Carrier non-radioactive α-pinene was added to the ether solution. The nitrosochloride was dissolved in toluene and counted by liquid scintillation as in Fig. 1
Melting point, 105–108° C.

Times recrystallized	(mgm.)	(c.p.m.)	Specific activity (c.p.m./mgm.)
3	2·2	165	75
4	1·2	95	79

the initial sample of mevalonic acid-2-^{14}C in November 1956.

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Effect of Simulated Field Deposits of Gamma-BHC and Dieldrin on Susceptible, Hybrid and Resistant Strains of *Anopheles gambiae*, Giles

SINCE the first recognition of resistance to dieldrin in *Anopheles gambiae* in Northern Nigeria[1], laboratory studies have shown the degree of resistance to this insecticide to be of a very high order—some 800 times—and that cross-resistance to gamma-BHC is involved, though of a comparatively low order—some 30 times[2]. This type of resistance has further been shown to be monofactorially inherited, the hybrid being intermediate in its resistance—some 30 times to dieldrin and only 8 times to gamma-BHC[3]. The resistant strain remains susceptible to DDT, though there has always been some doubt as to the efficiency of this insecticide in controlling malaria transmitted by *A. gambiae* because of the irritant effect of the insecticide and the consequent low mortalities achieved[4].

A series of observations has now been made to determine the effect of simulated field applications of commercial formulations of gamma-BHC and dieldrin on susceptible, hybrid and resistant strains of *A. gambiae* derived from colonies maintained at the Ross Institute of Tropical Hygiene, London. The main purpose of the experiment was to see if these applications would produce any mortality among the hybrid and resistant mosquitoes and, if so, for how long. In addition, the persistence of the two insecticides at similar dosages on sorptive mud blocks has been compared.

Blocks of a highly sorptive mud from Babati in Tanganyika, 3 in. in diameter and ½ in. thick, were kindly prepared and sprayed with insecticide by A. B. Hadaway and F. Barlow of the Colonial Insecticide Research Unit, Porton Down.

Gamma-BHC was applied at 25 and 50 mgm./ft.^{2} and dieldrin at 50 mgm./ft.^{2}, using in both cases 50 per cent dispersible powders. The test method used was for the most part similar to that employed by Hadaway[5]. A 'Perspex' exposure chamber was placed vertically against the treated surface of each mud block and approximately 20 unfed adult mosquitoes were transferred to the chamber from a collecting tube. The experiments were conducted in a constant temperature and humidity room (80° F., 75 per cent relative humidity). The mud blocks were stored between tests under these same conditions and the same blocks used for tests at successive dates. The exposure period of mosquitoes to the blocks ranged from 30 min. to 7 hr. according to the age of the residue. After exposure the mosquitoes were lightly anæsthetized with chloroform vapour and removed to net-covered paper cups where they were fed with 10 per cent glucose solution and held for 24 hr., at the end of which time the mortality was determined. Both male and female mosquitoes were exposed, and though in general the former showed a higher mortality than the latter, the combined mortality has been given in the final rendering of the results. As a control to the experiment mosquitoes were similarly exposed to an untreated mud block.

The results of these exposures up to 8 weeks after treatment of the mud blocks are given in Table 1. It can be seen that all three treatments give very high mortalities with susceptible *A. gambiae* throughout the two-month period when an exposure of one half-hour is made. Such high mortalities have in fact continued with both gamma-BHC and dieldrin at 50 mgm./ft.^{2} to the time of writing (13 weeks) with the same exposure time, though the lower dosage of gamma-BHC now only gives a mortality of about 40 per cent.

Table 1. PERCENTAGE MORTALITIES AMONG MALE AND UNFED FEMALE, SUSCEPTIBLE, HYBRID AND RESISTANT *A. gambiae* EXPOSED FOR VARYING TIMES TO RESIDUES OF GAMMA-BHC AND DIELDRIN OF VARYING AGES

Strain	Insecticide (mgm./ft.^{2})	Exposure period (hr.)	Age of residue				
			1 day	1½–2 weeks	3 weeks	6 weeks	8 weeks
Susceptible	Gamma-BHC 25	½	100	93	—	89	95
	Gamma-BHC 50	½	100	100	—	100	100
	Dieldrin 50	½	96	—	—	96	96
Hybrid	Gamma-BHC 25	½	100	69	11	0	—
		1½	—	—	—	66	4
		2	—	—	—	—	62
		3	—	—	—	—	60
		4	—	—	—	—	100
	Gamma-BHC 50	½	100	100	61	0	—
		1	—	—	100	83	39
		1½	—	—	—	100	67
		2	—	—	—	—	96
		3	—	—	—	—	100
	Dieldrin 50	1	94	47	5	6	—
		3	—	—	—	—	4
		7	—	—	—	—	32
Resistant	Gamma-BHC 25	½	45	—	—	—	—
		1	87	5	—	0	—
		7	—	—	—	—	24
	Gamma-BHC 50	½	88	—	—	—	—
		1	100	57	—	0	—
		3	—	—	—	—	20
		4	—	—	—	—	64
		7	—	—	—	—	84
	Dieldrin 50	1	5	0	—	7	—
		2	—	—	—	0	—
		7	—	—	—	—	0
Susceptible	Control	½	—	—	—	0	0
		1	0	16*	—	—	—
Hybrid	Control	½	—	—	0	—	—
		1	—	—	0	0	—
		2	—	—	—	0	—
		3	—	—	—	—	0
		4	—	—	—	—	0
		7	—	—	—	—	0

* Over-anæsthetized.

Fresh deposits of gamma-BHC gave complete mortalities of hybrid *A. gambiae* after exposure of ½ hr., and the higher dosage of gamma-BHC continued to give this mortality with the same exposure time up to 2 weeks after treatment. Dieldrin in the fresh state also killed most hybrids though exposure of 1 hr. was necessary. With ageing of the deposits longer and longer exposures were necessary to produce significant kills. After 8 weeks, 4 hr. exposure was necessary to kill all hybrids on the lower dosage of gamma-BHC and 7 hr. exposure to dieldrin only resulted in a third of the hybrids dying. The higher dosage of gamma-BHC continued to produce high mortality at much shorter exposure times.

The resistant *A. gambiae*, as might be expected, proved much more difficult to kill. In the fresh state both dosages of gamma-BHC gave high kills at quite short exposure times, but after 8 weeks 7 hr. exposure was necessary on the higher dosage to give a high mortality rate. Dieldrin never at any time gave satisfactory kills at the exposures given.

These results indicate that a persistent kill of hybrid *A. gambiae* by gamma-BHC with a consequent delay in the appearance of the resistant strain may be expected where this insecticide is used. However, it should be pointed out that this method of exposure in a small confined space may give rise to artificially high mortalities because of the accumulation of insecticide in the vapour state, a condition less likely to arise in Nature. It should also be pointed out that a resistant strain of the species did arise in Kano, Nigeria, as a result of the use of gamma-BHC, if not over a short period, then certainly over a comparatively small area[6].

The current conviction that two types of resistance occur in anopheline mosquitoes, one to DDT and the other to the dieldrin–BHC group of insecticides, and that the possibility of the two types occurring in one and the same population of the same species is very remote, has led to a consideration of the possible use of mixtures of insecticides for preventing the appearance of resistant strains. The choice would of necessity at present lie between DDT and gamma-BHC and DDT and dieldrin. In view of the marked irritant effect of DDT the chances of a mosquito escaping unharmed from a mixture would be greater where dieldrin is involved, owing to the lower toxicity of this insecticide compared with gamma-BHC. The results of the present experiments would further favour the choice of gamma-BHC in the mixture and indicate that a higher dosage than the customary 25 mgm./ft.^{2} will produce a persistence more in line with that of dieldrin at 50 mgm./ft.^{2}.

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Radioassay of Carbon-14 in Aqueous Solutions using a Liquid Scintillation Spectrometer

MOST compounds of biochemical interest have only limited solubility in organic solvents, and the useful fluors described to date have only limited solubility in aqueous solutions. This basic incompatibility has limited the application of liquid scintillation counting methods in many biochemical tracer studies. The method described below permits direct counting of aqueous solutions (or alcoholic solutions). In addition, it permits quantitative recovery of the sample in its original form for further analyses, often an important advantage when the quantity of sample available is limited.

The method is based on the principle of using a two-phase system: a solid phase consisting of a multitude of small, clear particles (plastic or glass) into which a fluor has been incorporated and a liquid phase containing the radioactive mixture to be assayed.

Preliminary experiments were carried out using small cylindrical filaments of 'Pilot Scintillator *B*' 3·2 cm. long and 0·043 cm. in diameter, which had been originally designed for use by physicists in particle-tracking experiments. A bundle of these filaments was packed tightly into a section of glass tubing (0·8 cm. × 4·4 cm.) and aliquots of a standard solution of aqueous sodium carbonate-^{14}C (National Bureau of Standards reference source), containing 1,280 disintegrations/sec./ml., were allowed to seep into the bundle by capillary action. The tube was placed upright in a Wheaton Glass Company counting vial and counted in a Packard 'Tricarb' scintillation spectrometer. As shown in Fig. 1 (inset), the corrected count-rate increased linearly with increasing volume of sample. The efficiency was 29 per cent. When the vial was allowed to stand in the refrigerated counting chamber for several hours, the count-rate was observed to rise markedly as the solution froze. Thawing returned the count-rate to the original value. Quick freezing, on the other hand, did not change the count-rate significantly. This rise in count-rate on slow freezing is attributable to separation of the solute phase so as to concentrate it in the vicinity of the beads. For routine use

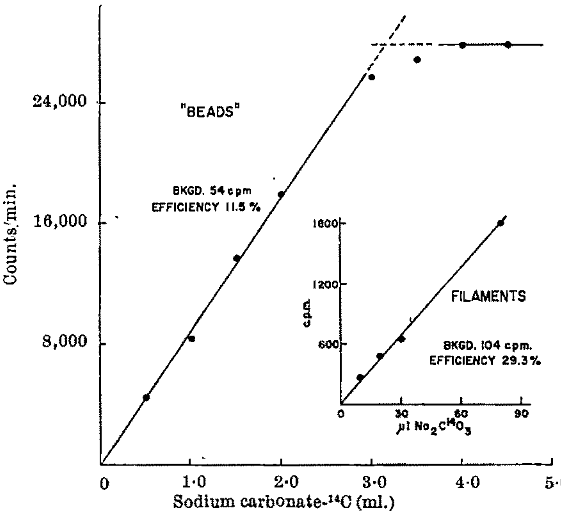

Fig. 1

aqueous samples should be counted above their freezing point. Because the filaments were very tightly packed, it was possible to rinse out the labelled solution without disturbing their packing, and, after rinsing with alcohol and drying, re-use them. A limitation of this method is that the geometry of the system makes it difficult to add an internal standard and be certain of complete mixing. Quenching correction could be determined by adding internal standard to a second aliquot and counting it separately. The hand-packing procedure is tedious and impractical, but if uniformly packed vials of filaments become available commercially, the use of this system might be feasible. A more practical system for routine use would employ uniform spherical beads of plastic scintillator.

The feasibility of the latter approach was explored by cutting the cylindrical filament into very short (1–2 mm.) segments. 4·4 gm. of these 'beads' (approximately 7·7 ml. in volume) were placed in a counting vial and successive aliquots of the aqueous radioactive sodium carbonate standard were added. The count-rate increased in proportion to sample size up to about 3·0 ml. (Fig. 1) and the absolute efficiency was 11·5 per cent. The count-rate then dropped off and reached a plateau as would be expected. With an excess of liquid sample added to a measured quantity of scintillator beads, the observed count-rate is directly proportional to the specific radioactivity of the solution in counts/min./ml. independent of the exact volume added, since the interstices are then completely filled with the labelled solution. This is quite analogous to the counting of solid samples at infinite thickness. It should be pointed out that the density of the plastic used here (1·02) was such that the 'beads' did not pack solidly and this accounts for some of the deviation from linearity seen in Fig. 1. In addition, of course, the simulated 'beads' cut by hand for this purpose were not uniform and did not pack homogeneously. Still, the large number of particles used appears to have resulted in reasonably reproducible average packing. Repeated counts on an aqueous solution of l-lysine-^{14}C, shaken up between counts, were 1,838, 1,773, 1,728 and 1,755 counts/min. Addition of water reduced the observed count-rate in proportion to the dilution of the original radioactive solution, demonstrating completeness of mixing and further validating the direct relation between count-rate and specific radioactivity in counts/min./ml.

Finally, it was shown that a correction for quenching can be accurately made in the usual way by adding a known amount of radioactivity in a minute volume, mixing and recording the increment in count-rate. If a constant quantity of 'beads' is used and an excess of radioactive solution, this internal standard correction also corrects for volume and makes it unnecessary to measure accurately the volume of solution being assayed, provided it completely covers the 'beads'.

The plastic scintillator used in this work, 'Pilot Scintillator B', containing diphenylstilbene, was supplied by Pilot Chemicals, Inc., Watertown, Mass., and I thank Mr. Mark Hyman, of that firm, for providing this material. Uniform short cylindrical segments will soon become available for distribution.

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Stability of Metal Complexes with Salicylic Acid and Related Substances

SALICYLIC acid and its derivatives can form chelate compounds with metal ions. Unfortunately, the paucity of data on stability constants in aqueous solutions[1] has prevented assessment of the biological significance of this property in the outstanding anti-rheumatic and anti-fungal actions of these substances, as well as in their toxic action to man in higher dosage.

Stability constants are now reported for the chelation of some cations with salicylic acid and some related substances. In near-neutral solutions the carboxyl-group of salicylic acid is almost completely ionized, so that simple complex formation with a metal ion would not lead to the considerable liberation of hydrogen ions found, and hence the metal ion must displace the hydrogen ion from the phenolic group. The resulting change in the pH of the solution enabled Bjerrum's potentiometric method[2] to be used to obtain the stability constants of the divalent cations. Where permissible, appropriate mathematical simplifications of the calculations were made[3]. In many instances hydrolysis or precipitation prevented direct determination of log K_2, so for all except cupric and ferric ion, log K_2 was obtained by subtracting log K_1 from log K_1K_2 (found at $\bar{n} = 1$). Constants for ferric complexes were calculated from the dependence on pH of oxidation-reduction potentials[4]. All solutions were titrated under nitrogen. Sodium perchlorate or perchloric acid was added to maintain an ionic strength of 0·15, thus approximating isotonicity with blood. All metals were added as perchlorates except cadmium (sulphate) and manganese (chloride). For all ligands except salicylaldehyde the ionization constant of the phenolic group was measured spectrophotometrically either in sodium hydroxide solution, using known activity coefficients[5] to calculate hydrogen ion concentrations, or in buffer solutions of known pH. All other ionization constants were determined by potentiometric titration.

Reliable ionization constants could not be obtained for salicylamide (which hydrolysed rapidly in alkaline solutions) or for the catechol anion (which oxidized very readily in air). The rough estimate of $pK_2 = 13$ for catechol was based on potentiometric titration under nitrogen.

The present value of log K_1 for the copper salicylic acid complex confirms Babko's[8] figure, but log K_2 is much higher than previously reported[8]. The stability constants of the ferric complexes of salicylic and sulphosalicylic acids are consistent with published[9] data and are much greater than for the corresponding copper complexes.

Stabilities of the complexes of the divalent metals conform to the Irving–Williams series[10]: Mn $<$ Fe $<$ Co $<$ Ni $<$ Cu $>$ Zn. The rather small increment in passing from manganese to nickel, with a greater increase from nickel to copper, is similar to results for other ligands in which bonding of the metal occurs with two oxygen atoms[11].

Table 1 shows that, of the o-substituted phenols examined, both salicylic and 5-sulphosalicylic acid are powerful chelating agents. However, to compare their chelating abilities under biological conditions with those of other ligands it is necessary to calculate from these results the distribution of selected cations between equal ligand concentrations at the same pH. This has been done in Table 2 for approximately neutral solutions of salicylic acid, sulpho-

Table 1. STABILITY CONSTANTS OF SOME METAL COMPLEXES, IN AQUEOUS SOLUTION AT 20° C.

Unless otherwise indicated, ligand concentrations were 0·05 *M* and metal ion concentrations were 0·005 *M*

Cation	Ligand	Log K_1	Log K_2
Mn^{++}	Salicylic acid	5·90	3·9^a
Fe^{++}	Salicylic acid	6·55^b	4·7^a
Co^{++}	Salicylic acid	6·75	4·7^a
Ni^{++}	Salicylic acid	6·95	4·8^a
Cu^{++}	Salicylic acid	10·60	7·85
Zn^{++}	Salicylic acid	6·85	pptn.
Cd^{++}	Salicylic acid	5·55	pptn.
Fe^{+++} (0·001 *M*)	Salicylic acid (0·01 *M*)	16·35	11·90
Mn^{++}	5-Sulphosalicylic acid	5·10	2·90
Fe^{++}	5-Sulphosalicylic acid	5·90	< 4·0
Co^{++}	5-Sulphosalicylic acid	6·00	3·60
Ni^{++}	5-Sulphosalicylic acid	6·30	3·90
Cu^{++}	5-Sulphosalicylic acid	9·50	6·80
Zn^{++}	5-Sulphosalicylic acid	6·05	< 4·6
Cd^{++}	5-Sulphosalicylic acid	4·65	pptn.
Fe^{+++} (0·001 *M*)	5-Sulphosalicylic acid (0·01*M*)	14·60	10·55
Cu^{++} (0·0025 *M*)	2-Hydroxyacetophenone (0·005 *M*)	6·75	5·70
Cu^{++} (0·0025 *M*)	Methyl salicylate (0·003 *M*)	5·90	
Cu^{++}	Salicylaldehyde (0·02 *M*)	5·75	pptn.
Cu^{++} (0·0025 *M*)	Salicylamide (0·005 *M*)	−3·40^c	−4·50^d
Cu^{++}	Catechol	1·25^c	0·65^d
Fe^{++}	Glycine (for comparison)	4·3^6	3·5^6
Cu^{++}	Glycine (for comparison)	8·5^6	6·9^6
Fe^{+++}	Glycine (for comparison)	10·0^4	
Fe^{++}	Oxine (for comparison)	8·0^6	7·0^6
Cu^{++}	Oxine (for comparison)	12·2^6	11·2^6
Fe^{+++}	Oxine (for comparison)	12·3^7	11·3^7

(*a*) Obtained at ligand concentration 0·15 *M*.
(*b*) In 0·1 *M* KCl.
(*c*) For $Cu^{++} + HL \rightleftharpoons CuL + H^+$.
(*d*) For $CuL + HL \rightleftharpoons CuL_2 + H^+$.

Ionization Constants for Ionic Strengths of 0·10–0·15

Ligand	*pK*	
Salicylic acid	2·98,	13·61
5-Sulphosalicylic acid	2·62,	11·95
2-Hydroxyacetophenone	10·06	
Methyl salicylate	9·87	
Salicylaldehyde	8·34	
Catechol	9·43,	~ 13
Glycine ($I = 0·01$) (ref. 6)	2·24,	9·85
Oxine ($I = 0·01$) (ref 7)	5·13,	9·89

Table 2. DISTRIBUTION OF CATIONS AMONG LIGANDS, IN NEUTRAL SOLUTION

	Salicylic acid	5-Sulphosalicylic acid	Glycine	Oxine
Cu^{++}	1	3·5	45	200,000
Fe^{++}	1	10	30	150,000
Fe^{+++}	400	300	1	200

salicylic acid, glycine and oxine (8-hydroxyquinoline). Glycine is a typical amino-acid with which salicylic acid and its derivatives would have to compete for metals in the mammalian body, while oxine resembles salicylic acid in being a powerful fungicide.

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Determination of Strychnine in Nux Vomica by Paper Chromatography

MOST methods used for the estimation of strychnine in nux vomica lead to gross inaccuracies due to brucine interference. Even oxidation of brucine with nitric acid under optimal condition (5 min. at 60° C.) leads to errors due to partial destruction of strychnine[1]. Gravimetric estimations also require amounts greater than 0·1 gm. in the sample[1].

Paper chromatography has also been applied, but most of the methods have difficulty in separating brucine from strychnine. Dušinský and Tyllová[2] have overcome this difficulty by using nitric acid to oxidize brucine to *o*-brucichinone. This method probably suffers from errors outlined by de la Vega and Del Pozo[1].

These can be obviated by using a simplified method. The aqueous sample was made alkaline with sodium hydroxide and the alkaloids were extracted with chloroform. The chloroform was then evaporated in a water-bath. The resulting alkaloids were dissolved in a measured volume of chloroform and aliquots of this extract, containing 60–20 γ strychnine, were spotted on to Whatman No. 1 chromatography paper and developed overnight with *n*-butanol/*n*-propanol/0·05 *N* hydrochloric acid (1 : 2 : 1 v/v) at 20° C. by the ascending technique. The paper was dried and photographed in the ultra-violet to reveal the spots. The paper was then cut and eluted with water. The strychnine hydrochloride was estimated using a Beckman spectrophotometer model *DU* at $\lambda_{max.}$ 255 mμ [3].

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Isolation of Piperonylic Acid from *Ocotea pretiosa*

As part of work on the chemical constituents of Brazilian Lauraceae[1], we examined the benzene extractives (2·4 per cent) of the wood of *Ocotea pretiosa* (Nees) Mez, the sassafras tree of the State of Santa Catarina producing essential oil (chiefly safrole). Through extraction with aqueous bicarbonate solution a solid (comprising 0·03 per cent of the wood) was isolated and purified by crystallization from chloroform and vacuum sublimation. White crystals were obtained, melting point 227–29° C. (Kofler block). Determination of the melting point of a mixture and infra-red spectral comparison with an authentic sample established its identity with piperonylic acid.

Piperonylic acid is, apparently, quite rare in Nature. Its known occurrence is restricted to the plant family Lauraceae, where traces of it have been found accompanying relatively much larger amounts of substances containing the piperonyl moiety. Only once before[2] has it been isolated by solvent extraction from a natural source, the coto barks, where it occurs along with 6-piperonyl-α-pyrone (*Aniba coto* Kostermans) and accompanying 6-piperonyl-α-pyrone, 2,4-dimethoxy-6-hydroxy-3′,4′-methylenedioxybenzo-

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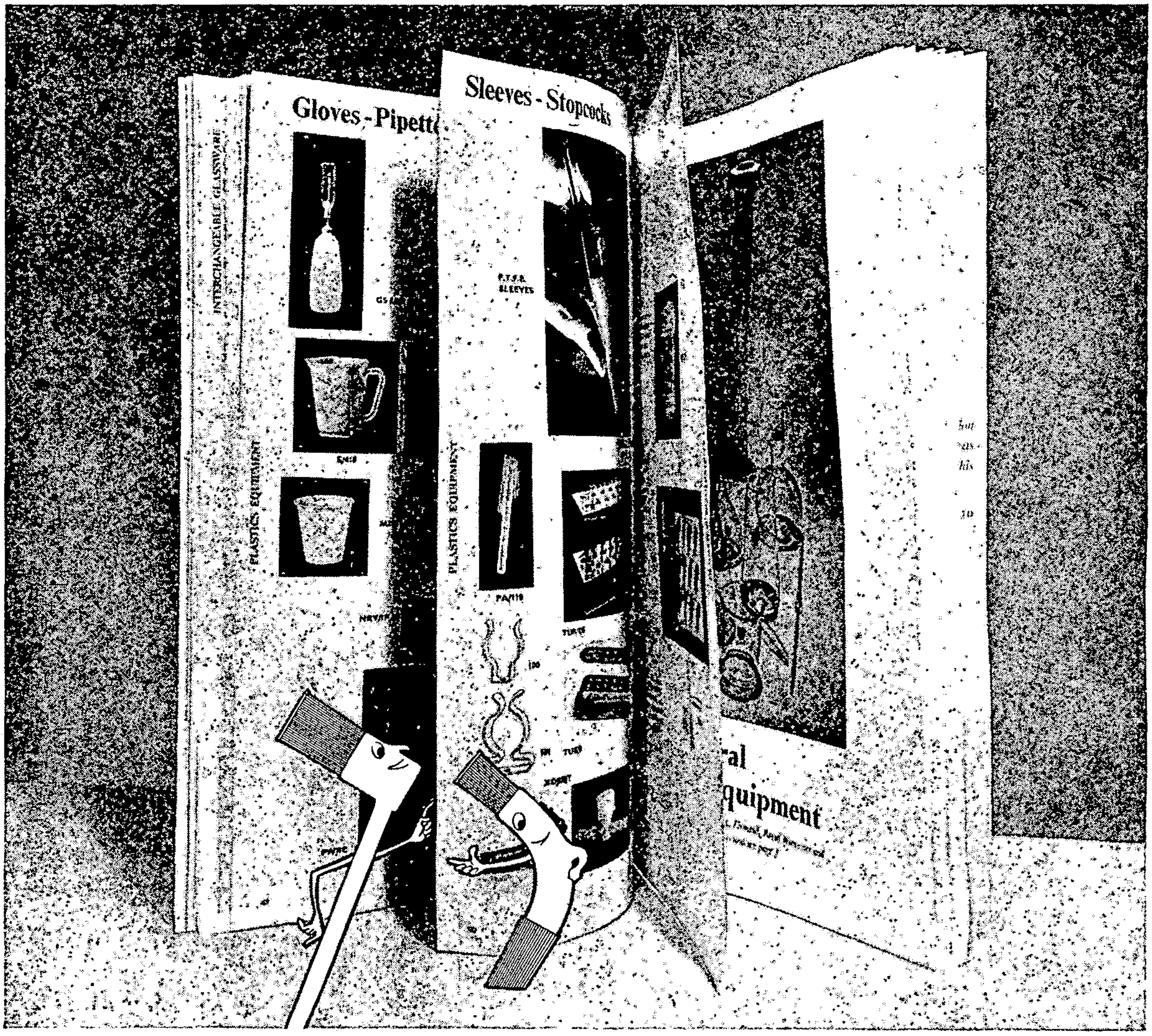

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phenone and 2,4,6-trimethoxy-3′,4′-methylenedioxybenzophenone (*Aniba pseudocoto* Kostermans). Although traces have also been found in steam-entrained camphor oils (accompanying safrole) from several *Cinnamomum* species[3,4], at least once[4] doubt has been expressed as to its actual presence in the plant.

Acknowledgment is due to the Conselho Nacional de Pesquisas, Brazil, for financial aid.

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Shape of Spot and Rate of Sorption in Paper Chromatography

Chromatography is characterized by a dynamic distribution of a substance between a stationary phase and a mobile phase in which diffusion occurs[1]. In the case of a linear sorption isotherm, the exchange reaction between the two phases may be considered to be of the first order.

In spite of this, most theories of chromatography are based on simple equilibrium considerations and diffusion is frequently neglected[1-3]. Although diffusion is considered in a series of papers on sorption-rates by Wicke[4], he considers sorption fronts only and does not apply his analysis to the exchange reaction which occurs in chromatography. In recent papers[5] Giddings has considered the exchange reaction using a discrete model of chromatography, thereby obtaining results similar to ours.

In the present communication we show for a simplified model how the diffusion in the mobile phase and the dynamic character of the exchange process may be taken into account. The random exchanges of a molecule between the adsorbed and the desorbed states interact with the bulk flow in the mobile phase to create a random motion, which is observed macroscopically as an additional diffusion superimposed on the ordinary diffusion in the mobile phase. We shall show that this increase in diffusion in the direction of the flow in the mobile phase may be derived from the general differential equations for the concentrations of adsorbed and desorbed molecules. These equations have been discussed by us in connexion with electrodiffusion[6].

In paper chromatography the spot is often observed to be elongated in the direction of the flow of the developer[1,7]. This fact has not yet to our knowledge been satisfactorily explained. We shall, however, show that for the simple model considered here and in the absence of secondary reactions or transformations on the paper, this may be explained as a consequence of the interaction between the exchange process and the bulk flow. By comparing the dimensions of the spot in the direction of developer flow and at right angles to that direction, it is possible to estimate the values of the rate constants for adsorption and desorption.

Consider a thin layer of a fluid phase streaming in the x-direction with uniform velocity v over a two-dimensional fixed phase. The substance which takes part in the chromatographic process is introduced at zero time at the point $x = y = 0$. We shall assume the initial distribution to be given by a δ-function with the whole amount of substance in the fixed phase. It will further be assumed that we can neglect diffusion in the fixed phase.

If the concentrations of the substance considered are c_1 in the mobile phase and c_2 in the fixed phase, the behaviour of the system, taking into account only motion in the x-direction, may be described by the partial differential equations:

$$\frac{\partial c_1}{\partial t} = D\frac{\partial^2 c_1}{\partial x^2} - v\frac{\partial c_1}{\partial x} - k_1 c_1 + k_2 c_2 \qquad (1)$$

$$\frac{\partial c_2}{\partial t} = - k_2 c_2 + k_1 c_1 \qquad (2)$$

D is the simple diffusion coefficient, whereas k_1 and k_2 represent the rates of adsorption and desorption, respectively, with respect to the fixed phase and include all effects due to the boundary layer and to diffusion at right angles to the fixed surface. A discussion of the relation between actual reaction-rates at the surface and diffusion towards the surface has been given by Prigogine[8].

These equations are solved by Fourier transforms with respect to x, retaining in the solution of the resulting ordinary differential equations only terms up to the first order in Dz^2, where z is the new independent variable. We obtain:

$$c_1 = \frac{k_2}{2(k_1 + k_2)\sqrt{\pi \mathbf{D}_x t}}\left(\exp - \frac{\xi^2}{4\mathbf{D}_x t}\right)[1 + f_1(\xi,t)] \qquad (3)$$

$$c_2 = \frac{k_1}{2(k_1 + k_2)\sqrt{\pi \mathbf{D}_x t}}\left(\exp - \frac{\xi^2}{4\mathbf{D}_x t}\right)[1 + f_2(\xi,t)] \qquad (4)$$

where $\mathbf{D}_x$ represents the 'effective diffusion coefficient' in the x-direction given by:

$$\mathbf{D}_x = \frac{Dk_2}{k_1 + k_2} + \frac{k_1 k_2}{(k_1 + k_2)^3}v^2 \qquad (5)$$

and ξ is a distance co-ordinate the origin of which is moving along with the maximum of concentration, that is,

$$\xi = x - \frac{k_2 v}{k_1 + k_2}t \qquad (6)$$

The functions $f(\xi,t)$ contain rapidly decaying transient terms.

After a time sufficiently long for the transient terms to become insignificant, the chromatography process in the simplified model considered may thus be described by an ordinary diffusion equation with diffusion constant $\mathbf{D}_x$ and distance co-ordinate ξ.

Following the same procedure as before, it is readily shown that the concentration distribution in the y-direction is given by:

$$c_i = \frac{k_i}{2(k_1 + k_2)\sqrt{\pi \mathbf{D}_y t}}\left(\exp - \frac{y^2}{4\mathbf{D}_y t}\right) \qquad (7)$$

where

$$\mathbf{D}_y = \frac{Dk_2}{k_1 + k_2} \tag{8}$$

The solution of the two-dimensional form in x and y of equations 1 and 2 is the product of the solutions 3 and 7, and it follows that the contour of the spot corresponding to a given concentration is an ellipse the principal axes of which, a_x and a_y, are proportional to the square roots of the effective diffusion coefficients in the x- and y-directions, that is :

$$\frac{a_x}{a_y} = \sqrt{\frac{\mathbf{D}_x}{\mathbf{D}_y}} \approx 1 + \frac{k_1 v^2}{2D(k_1 + k_2)^2} \tag{9}$$

The present theory thus provides not only a value for the rate of advancement of the spot but also gives an explanation for its shape. Furthermore, by comparing the two axes of the elliptical spot at different velocities, it is possible to deduce the values of the rate constants k_1 and k_2 for adsorption and desorption. More accurate values of the rate constants k_1 and k_2 may be obtained by measuring the rate of spreading of a spot or band at different velocities of developer flow.

We thank Prof. I. Prigogine for his interest in this work, which has been made possible by the support and sponsorship of the Air Research and Development Command, United States Air Force, through its European Office. One of us (W. G. K.) is indebted to the Commonwealth Scientific and Industrial Research Organization, Australia, for an overseas studentship, and the other (T. A. B.) to the University of Copenhagen for a grant in aid.

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Migration-elution of Zones in an Electrophoresis Column

So far the preparation of electrophoretically defined fractions by means of zone electrophoresis in powder columns has been performed in two separate steps. Electrophoresis has been succeeded by displacement of the solution in the column[1 2] or the entire contents of the column have been removed from the tube and cut in segments from which the substance has been recovered by washing[3,4]. Both methods obviously suffer from a number of drawbacks. The latter technique is rather time-consuming and is especially complicated when applied on a large scale (100-ml. sample or more). The former method is simple in operation but its main disadvantage is its dependence on the filtering properties of the powder. As Kunkel[4] has pointed out, the displacement of zones after electrophoresis will to some extent impair the separation already achieved at the end of the first step.

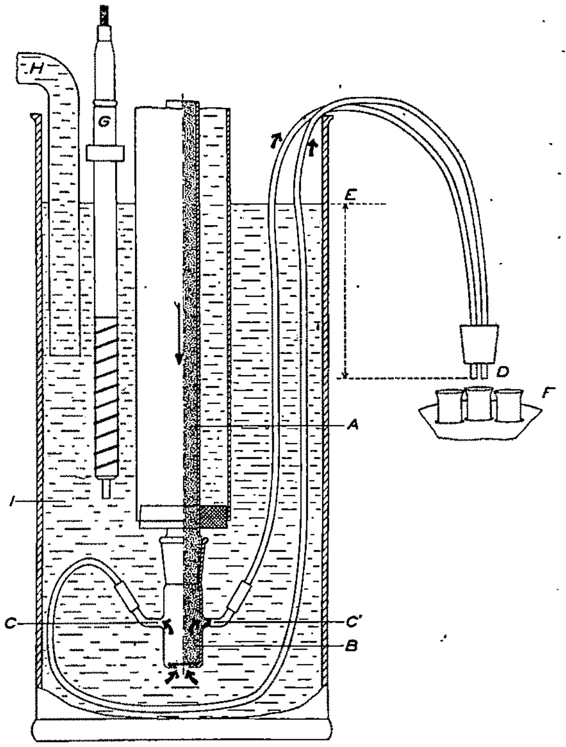

Fig. 1. Arrangement for continuous removal of zones during electrophoresis (see refs. 5 and 6). The electrophoresis column *A* is filled with powder surrounded by a cooling jacket and provided with the short column *B*. In addition to the column the electrode *G* and a tube *H* is dipped into the electrode vessel *I*. The tube *H* connects the buffer in *I* with a buffer reservoir for keeping the liquid-level *E* constant

We have found it possible to remove continuously the zones at a fixed level in the column by a buffer flow operating in the direction opposite to the electrophoretic migration. A simple arrangement for the utilization of this principle is shown in Fig. 1. In column *A* the zones move electrophoretically towards the bottom and pass a thick filter paper and a platinium net at the end of *A*. After entering a second short column *B* attached to *A* they meet a counter current of buffer solution. This causes the displacement of the zones through the side arms *C* and *C'* and through two capillaries the other ends of which are placed above a tube in a fraction collector *F*. The counter flow of liquid, which is determined by the hydrostatic pressure head *ED*, should be adjusted so that it safely exceeds the electrophoretic migration velocity of the fastest moving zone. Too high a rate of flow should be avoided, of course, since it will unduly dilute the samples to be collected. For obvious reasons the liquid flow should be decreased with time if the electric field-strength is kept constant during the experiment. A continuous decrease of the rate of flow proportional to the time should be most convenient.

The side arms may be placed directly at the lower end of *A* or at the upper end of the tube if electrophoretic migration upwards is preferred. However, the arrangement in Fig. 1 makes it possible to fill the tubes *A* and *B* with different anticonvection media. This opens up new fields of application of column electrophoresis. If the tube *A* is filled with a material

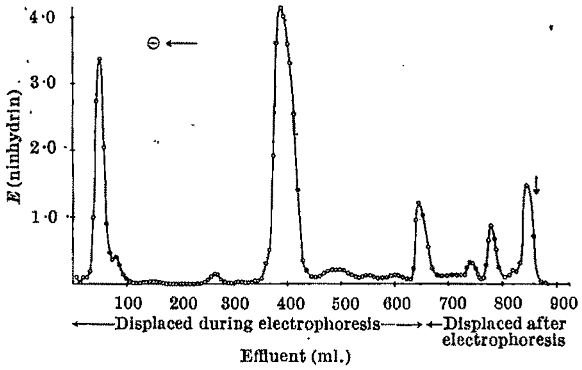

Fig. 2. Electropherogram of a mixture of basic peptides of the posterior lobe of pig pituitary (starting zone marked by the arrow). The sample had been obtained after a number of purification steps, including extraction, precipitation, ion-exchange chromatography and counter-current distribution. The large peak at the effluent volume of 400 ml. corresponds to lysine-vasopressin. When about 640 ml. of effluent had been collected during the electrophoretic run, the electrophoresis was stopped and the substances still remaining in the column were displaced by fresh buffer solution

of good stabilization but poor filtering properties such as a plastic powder or even a gel and if *B* is filled with powder suspension, a continuous displacement of zones should be possible with the retention of a high degree of resolution. Such experiments are now in progress.

Fig. 2 illustrates the result of an application of the method. The experimental details were as follows: 200 mgm. of a mixture of basic peptides from the posterior lobe of pig pituitaries were dissolved in 1 ml. of 0·3 *M* pyridinium acetate solution (*p*H 4·9) containing 0·5 per cent phenol as a preservative. The solution was applied at the top of a cylindrical column 71 cm. long, 2 cm. wide, cooled externally and containing the same buffer stabilized by cellulose powder[7]. The solution was allowed to sink into the column by the force of gravity and was displaced by fresh buffer to a position 2 cm. below the upper surface. The small column *B* was now attached to the lower end of *A* (Fig. 1) and immersed in the buffer of electrode vessel *I*. Liquid connexion with the other electrode vessel was established as described elsewhere[5,6] and the free ends of the capillaries *D* were placed over the fraction collector. The column *A* was cooled by circulating tap water of +10° C. through the cooling jacket. A potential difference of 480 V. between the electrodes resulted in a current of 40 m.amp. After 22 hr. the elution through the capillaries was started while continuing the electrophoresis. One 5·9-ml. fraction was collected every half hour. After 71 fractions had been collected the pressure head *ED* was decreased to yield 3·6 ml./hr. and one fraction was collected hourly. From fractions 115 to 142, 2·3 ml. of eluent an hour was removed from the column. The electrophoresis was now stopped and the material remaining on the column displaced by fresh buffer at a rate of 5·3 ml./hr. One fraction was collected every 5 min. Ninhydrin values according to Moore and Stein[8] were determined on 0·5 ml. aliquots from each sample. The distribution curve is shown in Fig. 2. The large peak in the middle corresponds to lysine-vasopressin.

This is part of a programme on the development of zone electrophoresis methods at this Institute. It has been financially supported by the Swedish Natural Science Research Council, the Rockefeller Foundation, the Wallenberg Foundation and the U.S. Department of Army, through its European Office, under contract number *DA*–91–508–*EUC*–287.

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Neutron Production and Temperature in ZETA

It is assumed that thermalization and high temperature have been achieved in ZETA[1], although theoretical considerations demand a much longer period than that available for the process to take place[2]. This discrepancy between apparently observed and the theoretically expected thermalization time may be due to unknown processes occurring which speed up the process of thermalization[2]. This explanation, however, does not seem to be valid. Moreover, it is possible to explain most of the observed facts, if one assumes a 'betatron type' of acceleration of deutrons in ZETA, for the following reasons:

(*a*) Theoretical and experimental work[3–5] have shown that under suitable conditions 'run-away electrons' are produced in gas discharges; that is, under certain conditions the cross-section for electron – ion collision is small. This implies that under these conditions the ions can move freely through the electrons with mean free paths much larger than those computed from considerations of plasma density.

(*b*) Using the method of estimating critical velocity for 'run-away electrons'[5] and the equations of Spitzer[6], the critical energy required for ions to be continuously accelerated against ion–ion collision losses is $W = 3\cdot2 \times 10^{-14}\, n/V$ electron volts, where n is the number of ions per cm.³ and V is the electric field in volts per cm. In ZETA, with $n = 6 \times 10^{13}$ and initial value of $V = 2$ volts per cm., $W = 1$ eV. Thus, even at room temperature there is an appreciable number of ions (about 10^{8}) out of a total of about 10^{19} ions in ZETA, which could be accelerated. The number of neutrons produced per pulse is also of a similar order; but this may be just a coincidence. The initial adiabatic compression could contribute still further to this number of eligible ions.

Once the ions are in a condition suitable for acceleration, an average field of 1 V./cm. could accelerate the ions to 60 keV. in 0·5 m.sec. or to 240 keV. in 1 m.sec. The azimuthal magnetic field due to 2×10^{5} amp. is sufficient to confine ions of even higher energy; but ions of very high energy may not be produced because of the chance of ion loss by ending in nuclear reactions with the large number of relatively stationary ions.

If this mode of ion acceleration is accepted, it is easy to resolve the difficulties in explaining most of the facts observed with ZETA.

(1) Some of the deutrons undergo 'betatron type' of acceleration and gain enough energy in the observed time of about 0·5–1 m.sec. and produce neutrons by colliding with the large number of relatively slow-moving ions, as explained above. The difficulty about thermalization time[3] automatically vanishes.

(2) The anisotropy of neutron energy observed by means of photographic emulsion technique cannot be explained by any process of thermalization; but it is a necessary corollary of this method of acceleration of ions. (This experiment was mentioned during a lecture at the Tata Institute on May 19, 1958, by Dr. T. E. Allibone, to whom this possibility of acceleration of ions in ZETA was briefly mentioned.)

(3) The oxygen and nitrogen atoms in the discharge could gain random energy perpendicular to the discharge axis due to scattering by accelerated deutrons, and this could explain the observed Doppler broadening of their spectral lines when observed perpendicular to the discharge axis. If these ions also acquire a large drift velocity due to the collision of deuterons and the electric field, observation of the spectrum in a direction tangential to the discharge should reveal a Doppler shift as well.

(4) The observed decrease in neutron production with any increase of initial gas pressure could be due to the increase in the critical energy, which will reduce the number of ions eligible for acceleration.

In the light of this explanation, ZETA is a zero energy toroidal accelerator somewhat similar to that proposed by Budker[7]. The ions move in a direction opposite to that of the electrons and behave like a one-dimensional gas which is not in thermodynamic equilibrium and hence not obeying Maxwell's distribution law. Temperature assignment to such a gas has only dubious value. Nevertheless, this does not preclude the possibility of a fusion reactor of the type of ZETA, even though it may never be a truly thermonuclear reactor.

I am grateful to my colleagues, Mr. S. S. Bhave, Dr. A. S. Divatia, Mr. M. K. Mehta and Dr. A. P. Thatte, for stimulating discussions.

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Ductility of Chromium deposited from Molten Chloride Baths

Some time ago[1], we reported that chromium was deposited from certain molten chloride baths as hexagonal crystals which are transformed on cooling to the cubic form, as shown by X-ray examination.

In our further study of ductility in these crystals, we have found that while a low oxygen-level (less than 0·02 per cent) is necessary for ductility, the position of the oxygen in the lattice is also important. This position is, we believe, reflected in electrode potential. With a given oxygen content ductility is always associated with lower electrode potential against pure chromium. The hexagonal crystals show a break in the electrode potential temperature curve when measured against ordinary chromium. This is shown in Fig. 1. Ductility is thought to be determined by the mechanism of transformation from the hexagonal to the cubic form, and particularly by the distribution of impurities in the new lattice.

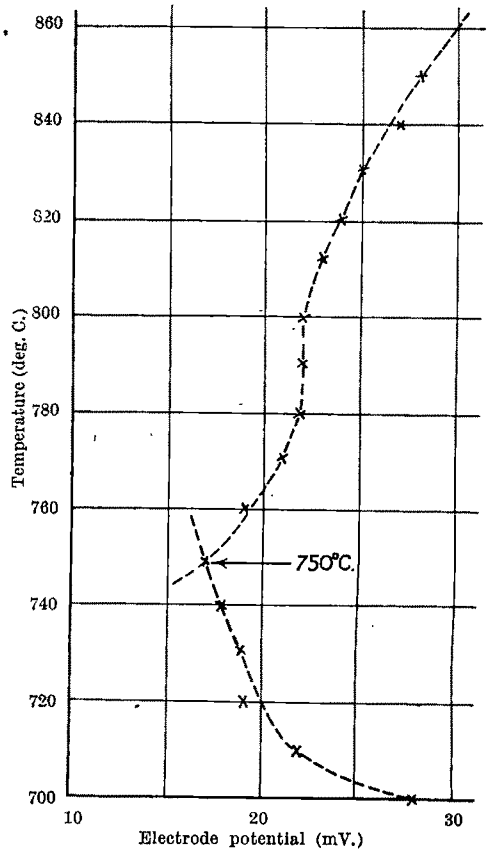

Fig. 1. Cooling curve of our chromium against commercial chromium

If crystal growth takes place along an uninterrupted screw axis, then the chromium is ductile by deformation along these axes. The photomicrograph (Fig. 2) is of a platelet of chromium from fused salt electrolysis bent 135° and cut and polished on the plane of the original platelet. The etch is electrolytic.

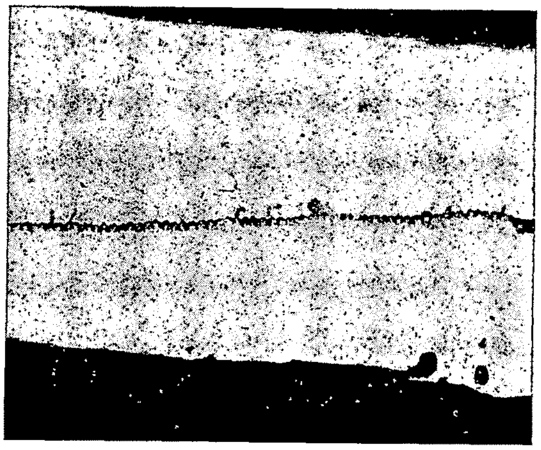

Fig. 2. Platelet of chromium, bent 135° and cut and polished on the plane of the original platelet. (× 75)

Many such screw 'deformations' occur in bending chromium platelets of this kind.

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A Highly Sensitive Chemical Dosimeter for Ionizing Radiation

An aqueous dosimeter capable of measuring radiation doses of less than 100 rads would be an extremely useful tool in the field of radiobiology. Although doses of a few rads can be accurately measured using the resorcinol-stabilized tetrachlorethylene-dye systems[1], such systems where the radiation-induced reaction proceeds by a chain mechanism exhibit certain undesirable characteristics. An alternative to the radiation-induced chain reaction involves the measurement of extremely small amounts of an irradiation product by means of a sensitive analytical technique. Some idea of the extreme sensitivity required is obtained from the fact that a dose of 100 rads will produce approximately 10^{-7} moles of product per litre of solution, assuming a reasonable production-rate of unity for $G_{\text{prod.}}$ (that is to say, 1 molecule of product formed per 100 eV. absorbed). An analytical method capable of accurate measurement at such high dilution is spectrophotofluorometry. The production of salicylic acid (which fluoresces in aqueous solution) in irradiated aqueous solutions of benzoic acid seemed to merit investigation, especially because this reaction had been proposed[2] as suitable for chemical dosimetry.

During irradiation a mixture of the three isomeric hydroxybenzoic acids is produced in the ratio of 5 : 2 : 10 for the *o* : *m* : *p* isomers respectively[3]. However, at 400 mμ (exciting wave-length 290 mμ) the fluorescent intensity of the *m* and *p* isomers is small compared with that of salicylic acid and can be neglected. Diphenyl has also been identified as a radiation product, but it does not fluoresce at 400 mμ if excited at 290 mμ. The fluorescent intensity of salicylic acid solutions is a linear function of concentration in the range 10^{-7}–10^{-8} *M*, and is independent of acidity from *p*H 5–11. Since the reproducibility of the measurements was only about ± 10 per cent, presumably because of the fluctuations in the intensity of the light source of the Aminco–Bowman spectrophotofluorometer, each experimental run was calibrated separately in the following manner. The fluorescent intensities of two standard salicylic acid solutions were measured immediately before and immediately after measurements were carried out on a series of irradiated solutions, and the salicylic acid concentrations in the latter solutions were computed using the average value of the 'fluorescence coefficient':

$$\text{Fluorescent coefficient} = \frac{\text{fluorescent intensity of standard}}{[\text{salicylic acid}]}$$

All dose-rates were determined using the ferrous sulphate $-0{\cdot}8\,N$ sulphuric acid dosimeter[4]. Corrections for the decreased energy absorption in water were made as described previously[5].

From Fig. 1 it is seen that the concentration of salicylic acid in irradiated $10^{-4}\,M$ calcium benzoate solutions (*p*H 5) increases in a linear fashion with dose of X- and γ-radiation over the range 0–100 rads, and is independent of dose-rate over the range 4–50 rads/min. For a given dose the fluorescent intensity is almost identical for cobalt-60 and cæsium-137 γ-rays. The rates of salicylic acid production expressed as $G_{\text{Sal.}}$ were computed to be:

Incident radiation	Co^{60} γ-rays	Cs^{137} γ-rays	300-kV. peak X-rays	100-kV. peak X-rays
Effective energy (MeV.)	1·25	0·66	0·16	0·05
$G_{\text{Sal.}}$	0·63 (15·5)	0·63 (15·5)	0·63 (15·5)	0·52 (13·8±0·5)

The values in parentheses refer to the values of the oxidation yield of the ferrous sulphate dosimeter used in the computation of $G_{\text{Sal.}}$

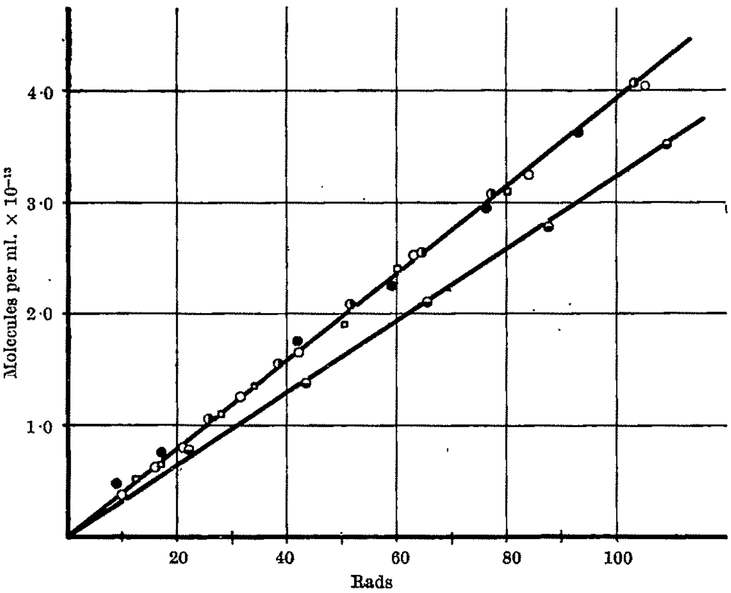

Fig. 1. ⊖, 100-kV. peak X-rays (20 rads/min.); □, 300-kV. peak X-rays (17 rads/min.); ●, 600-keV. cæsium-137 γ-rays (4 rads/min.); ○, 1·25-MeV. cobalt-60 γ-rays (20 rads/min.); ◑, 1·25-MeV. cobalt-60 γ-rays (50 rads/min.)

It is interesting to note that the $G_{\text{Sal.}}$ values are in reasonable agreement with the value of 0·73 deducible from the results of Weiss and co-workers[3] on the irradiation of $1{\cdot}6 \times 10^{-2}\,M$ solutions of benzoic acid at *p*H 5 with 200-kV. peak X-rays.

These preliminary experiments indicate that doses of electromagnetic radiation in the range 5–100 rads may be accurately measured (about ± 5 per cent) from the fluorescence induced in calcium benzoate solutions. It is hoped to extend these experiments to the measurement of doses below 5 rads.

W. A. Armstrong
D. W. Grant
Defence Research Chemical Laboratories,
Ottawa, Ontario.
July 8.

[1] Hine, G. J., and Brownell, G. L., "Radiation Dosimetry", Chapter 8 (Academic Press, Inc., New York, 1956).

[2] Day, M. J., and Stein, G., *Nature*, **164**, 671 (1949).

[3] Loebl, H., Stein, G., and Weiss, J., *J. Chem. Soc.*, 405 (1951).

[4] Weiss, J., Allen, A. O., and Schwarz, H. A., Proc. Int. Conf. Peaceful Uses of Atomic Energy, **14**, 179 (1955).

[5] Grant, D. W., Ph.D. thesis (Leeds, 1957).

FORTHCOMING EVENTS

Monday, September 15

Institute of Metal Finishing (at Northampton Polytechnic, St. John Street, London, E.C.1), at 6.15 p.m.—Prof. Ernst Raub (W. Germany): "Recent Research on Macro- and Micro-Throwing Power".

Wednesday, September 17

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5.30 p.m.—Dr. T. Salomon (Institut Français du Pétrole): "Harmful Effects of Electrostatic Charges on Machinery and Lubricating Oils".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Senior Research Associate in Upper Atmospheric Physics, for duties including experimental and observational research on the airglow and auroræ—Prof. D. R. Bates, F.R.S., Department of Applied Mathematics, The Queen's University, Belfast (September 20).

Lecturer or Assistant Lecturer (with interests in palæontology, stratigraphy or sedimentology) in Geology at St. Salvator's College—The Joint Clerk to the University Court, College Gate, St. Andrews (September 22).

Senior Scientific Officer (with a first- or second-class honours degree, preferably in biochemistry, and at least three years' post-graduate experience, or equivalent qualifications) at the Royal Air Force Institute of Pathology and Tropical Medicine, Halton, for work on clinical biochemical research, development and application of medical biochemical techniques related to aviation pathology and routine chemical use, and to give some assistance in teaching—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.594/8A (September 29).

Director (with good academic qualifications and of proven scientific leadership and administrative ability) of the Cawthron Institute, to develop researches primarily into plant nutrition problems of horticulture and agriculture—The Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, New Zealand, or the New Zealand High Commissioner, 415 Strand, London, W.C.2 (September 30).

Lecturer (with an honours degree and professional experience, preferably with special interest in concrete and reinforced concrete) in Civil Engineering—The Registrar, King's College, Strand, London, W.C.2 (September 30).

Lecturer or Assistant Lecturer in Economics—The Registrar, University College of North Staffordshire, Keele, Staffs (September 30).

Lecturer in Inorganic Chemistry at the University of Canterbury, Christchurch, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, September 30).

Senior Lecturer or Lecturer in Mathematics at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (September 30).

Senior Lecturer or Lecturer in Geology at the University of Auckland, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 4).

Chair of Soil Science in the Institute of Agriculture, University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 8).

Lecturer in Agricultural Chemistry at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 10).

Junior Lecturer in Botany—The Registrar, Trinity College, Dublin (October 11).

Professor of Mathematics at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (October 13).

Lecturer or Assistant Lecturer (able to teach in comparative physiology) in Zoology at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 15).

Senior Lecturer/Lecturer in Geography at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 14).

Senior Lecturer in Anatomy (Gross Anatomy) at the University of Melbourne, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (November 30).

Assistant Conservator of Forests (with a university degree in forestry, and preferably experience or training in surveying) in Nyasaland—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.61/4/01.

Assistant Lecturer in Mathematics—The Secretary, Royal College of Science and Technology, Glasgow.

Chair of Metallurgy—The Secretary, Royal College of Science and Technology, Glasgow.

Chemist, Scientific Officer grade (graduate with a good first- or second-class honours degree, preferably with a knowledge of high vacuum techniques), to undertake research with radioactive gases involving the separation of mixtures and thermal diffusion of gaseous isotopes—The Group Recruitment Officer, United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Didcot, Berks, quoting 1195/34.

Entomologist (with a good honours degree in natural science and some research experience in entomology) with the Department of Agriculture, Trinidad, to carry out research on biology and control of insect pests of coconuts and to co-operate in assessing their importance as vectors of red ring disease—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/38/01.

Lecturer (with a good honours degree in chemistry, or F.R.I.C., preferably with the desire and ability to undertake research) in Inorganic Chemistry, at Coventry Technical College, to teach subject to Grad.R.I.C. standard—The Director of Education, Council Offices, Coventry.

Zoologist (with a good honours degree and an interest in parasitology, preferably with a knowledge of chemistry) in the Helminthology Department—The Head, The Wellcome Laboratories of Tropical Medicine, 183–193 Euston Road, London, N.W.1.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Scottish Agricultural Improvement Council: Fruit Trials Committee. Report on Fruit Trials in Scotland, 1949–1956. Pp. 38. (Edinburgh: Edinburgh and East of Scotland College of Agriculture; Aberdeen: North of Scotland College of Agriculture; Glasgow: West of Scotland Agricultural College; Invergowrie: Scottish Horticultural Research Institute, 1957.) [227

Animal Behaviour (formerly *The British Journal of Animal Behaviour*), Vol. 6, Numbers 1 and 2 (January–April, 1958). Published twice yearly. Annual subscription 50*s.*; U.S.A. and Canada 8 dollars. (London: Baillière, Tindall and Cox, Ltd., 1958.) [227

Glasshouse Crops Research Institute. Annual Report, 1956. Pp. 140+4 plates. (Littlehampton: Glasshouse Crops Research Institute, 1958.) [227

Science and the Idea of God. By Prof. C. A. Coulson. (The Eleventh Arthur Stanley Eddington Memorial Lecture, 21 April, 1958.) Pp. vi+51. (Cambridge: At the University Press, 1958.) 4*s.* 6*d.* net. [227

Department of Scientific and Industrial Research. Building Research 1957: The Report of the Building Research Board with the Report of the Director of Building Research. Pp. iv+75+16 plates. (London: H.M. Stationery Office, 1958.) 5*s.* 6*d.* net. [227

Royal Botanic Gardens, Kew. Kew Bulletin, Additional Series, 1: *Indigofera* (*Microcharis*) in Tropical Africa, with the related genera *Cyanopsis* and *Rhynchotropis*. By J. B. Gillett. Pp. i+166. (London: H.M. Stationery Office, 1958.) 30*s.* net. [227

Overseas Geological Surveys: Mineral Resources Division. Gypsum and Anhydrite. By Dr. A. W. Groves. Pp. iv+108. (London: H.M. Stationery Office, 1958.) 7*s.* 6*d.* net. [227

Other Countries

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir No. 286: The Arthropod Fauna of the Upper Carboniferous Rocks of the Maritime Provinces. By M. J. Copeland. Pp. v+110 (21 plates). 1.25 dollars. Memoir No. 287: The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills. By Hans Frebold. Pp. xi+197 (44 plates). 2.75 dollars. (Ottawa: Queen's Printer, 1958.) [227

New Zealand Forest Service: Forest Research Institute. British Commonwealth Forestry Conference, Australia and New Zealand, 1957. Technical Paper No. 14: Timber Preservation in New Zealand. By D. R. Carr. Pp. 19. Technical Paper No. 21: Integration of Forest Research and Forest Products Research. By J. S. Reid. Pp. 8. Technical Paper No. 23: The Importance of Grading in Timber Utilisation. By W. C. Ward. Pp. 16. (Wellington: Government Printer, 1957.) [227

World Health Organization. Technical Report Series. No. 146: Expert Committee on Water Fluoridation—First Report. Pp. 25. 1 Swiss franc; 1*s.* 9*d.*; 0.30 dollars. No. 148: Joint FAO/WHO Expert Committee on Brucellosis—Third Report. Pp. 51. 2 Swiss francs; 3*s.* 6*d.*; 0.60 dollars. (Geneva: World Health Organization, London: H.M. Stationery Office, 1958.) [227

Western Region of Nigeria. Annual Report on the Forest Administration of the Western Region of Nigeria for the year 1955–56. Pp. ii+34. (Western Region, Nigeria: Government Printer, 1958.) [227

Eesti Loodus, Nr. 1 (Veebruar, 1958). ("Estonian Nature.") Pp. 64+4 tahvel. (Tartu: Academy of Sciences of the Estonian S.S.R., 5 Hariduse St., 1958.) Rbl. 3. [227

U.S. Department of Health, Education and Welfare: Public Health Service. A Directory of Medical and Biological Research Institutes of the U.S.S.R. Compiled by David P. Gelfand. Pp. vi+340. (Public Health Service Publication No. 587.) (Washington, D.C.: Government Printing Office, 1958.) [227

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0.6-0.9	14-52,**	52-100,	100-200,	< 200

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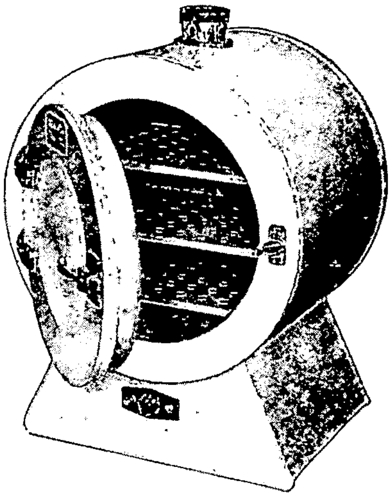

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LECTURES AND COURSES

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DEPARTMENT OF PHYSICS

Session 1958-59: Postgraduate Evening Courses are resumed on September 22, 1958. Subjects available: Acoustics and Vibration Physics; Nuclear Physics; Optics; Physical Electronics; Quantum Mechanics; Semi-conductors: Electromagnetism. Ancillary courses include Electronic Circuits. Enrolment: Tuesday, September 16, and Wednesday, September 17, 6 to 8 p.m.

Further details and application forms from the Secretary, Physics Department, Chelsea College of Science and Technology, Manresa Road, S.W.3.

SCHOOL OF ORIENTAL AND AFRICAN STUDIES

UNIVERSITY OF LONDON, W.C.1

MODERN ARABIC

An Intensive Introductory Course will be held from October 1 to December 10, 1958. Instruction will be given in basic grammar, translation, Press and Radio Arabic, the grammar of Colloquial Arabic, and general Middle Eastern topics. Fee: £40 10s. per head.

Inquiries to the Organizer of Special Courses.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

DEPARTMENT OF CHEMISTRY

ANALYTICAL METHODS

A series of postgraduate lectures on more recent analytical techniques will be held during the Autumn Term on Tuesdays at 7 p.m., commencing on October 7, 1958. The topics will include spectroscopic methods, solvent extraction, square wave polarography, radio-activation, isotopic dilution, inorganic paper chromatography, silicate analysis, nuclear magnetic resonance and organic sub-micro analysis.

A leaflet giving full details, and an application form, may be obtained from the Head of the Chemistry Department, Chelsea College of Science and Technology, Manresa Road, London, S.W.3.

OFFICIAL APPOINTMENTS

DIRECTOR

CAWTHRON INSTITUTE, NELSON, N.Z.

Applications for the above position are invited from those who are academically well qualified, of proven scientific leadership and administrative ability, to develop researches primarily into plant nutrition problems of horticulture and agriculture. Salary scale £2,000 to £2,250.

Details are obtainable from the Managing Secretary, Cawthron Institute Trust Board, Box 29, Nelson, N.Z., or the N.Z. High Commissioner, 415 Strand, London, with either of whom applications close on September 30, 1958.

SENIOR SCIENTIFIC AND SCIENTIFIC Officers, required at Government Communications Headquarters, Cheltenham, for telecommunications and electronic research in following fields: V.H.F. receiver design and microwave techniques; propagation trials; applications of semi-conducting devices; high speed electronic switching; data storage and handling: computer programming, and operational research. Candidates must normally be natural born British subjects of natural born British parents. First- or second-class honours degree in physics, mathematics or engineering or equivalent, at least three years' postgraduate experience for Senior Scientific Officer. Salaries for men (provincial rates) Senior Scientific Officer, £1,130 to £1,330; Scientific Officer, £595 to £1,050 (according to age and qualifications). Appointments unestablished but opportunities to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A147/8A.

CHEMIST REQUIRED BY NATIONAL Coal Board's Mining Research Establishment, Worton Hall, Isleworth, Middlesex, to assist in investigations into problems associated with the corrosion and deterioration of steel and other materials in coal mining conditions, and their protection by metallic or organic coatings. Applicants should have a good honours degree in chemistry. Appointment (superannuable) within inclusive scales £690 to £1,202 male, £674 to £1,147 female, depending on qualifications and experience. Five-day week; generous sick leave and holidays; staff canteen.—Write to Personnel Officer (X.1191/2) at above address, for application form which should be completed and returned by September 25, 1958.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISION OF LAND RESEARCH AND REGIONAL SURVEY

APPOINTMENT OF ECOLOGIST

Applications are invited for appointment to a position of Ecologist with the Division of Land Research and Regional Survey. The appointee will be a member of the Division's scientific unit which, for the past twelve years, has been conducting potentiality surveys mainly in undeveloped regions. Studies in the geology, geomorphology, pedology, botany and climatology of the regions are co-ordinated, and the officer will be expected to contribute to composite reports and to publish individual specialist papers. The appointee will make field studies with the unit for three to four months most years and the rest of the year at headquarters in Canberra, A.C.T., for compilation of maps, reports and papers dealing with the field surveys and subjects arising from them. The work will involve extensive use of aerial photographs, and their interpretation, and travel to many parts of Australia. Applicants should have a university honours degree in science, or agricultural science with botany, as a major subject, and research and field experience in plant ecology. Training in allied subjects such as soil science is desirable. The appointee will be classified as Research Officer, £A.1,326 to £A.1,951 per annum, or Senior Research Officer, £A.2,061 to £A.2,336 per annum, and commencing salary will be determined according to qualifications and experience. The appointment will be conditional upon a satisfactory medical examination and appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges. Fares to Australia, including those of wife and dependent family, will be provided by the Organization. Details may be discussed with the undersigned.

Applications, quoting Appointment No. 570/64, and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service, if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned from whom further particulars may be obtained by October 11, 1958.

E. J. DRAKE,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, London, W.C.2.

HAMPSHIRE EDUCATION COMMITTEE

FARNBOROUGH TECHNICAL COLLEGE

Principal: Mr. R. D. Peggs, O.B.E., M.A., M.I.Mech.E., F.R.Ae.S.

Applications are invited for the following posts:

(1) Assistant Lecturer (Grade B) in Electrical Engineering to assist in courses for O.N.C. and H.N.C. in Electrical Engineering. Industrial experience preferable.

(2) Assistant Lecturer (Grade B) in Applied Physics for O.N.C. course developing to H.N.C. level in Session 1959/60. Industrial experience preferable.

The salary for the posts will be in accordance with the Burnham Scale—Grade B (men) £650 by £25 to £1,025 with the usual allowances for training, qualifications and industrial experience, e.g., £125 for a good honours degree.

Further particulars and application forms may be obtained from the Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants, to whom they should be returned as soon as possible.

R. M. Marsh, County Education Officer, The Castle, Winchester.

UNIVERSITY OF MALAYA

SINGAPORE

Applications are invited for (A) Lectureship or (B) Assistant Lectureship in Biochemistry. Salary scales: For medically qualified candidates (A) £1,295 by £49 to £1,442/£1,540 by £56 to £1,988 per annum. (B) £1,148 by £49 to £1,246 per annum. For non-medically qualified candidates (A) £1,148 by £49 to £1,442/£1,540 by £56 to £1,820 annum. (B) £1,001 by £49 to £1,099 per annum. Entry point determined by qualifications and experience. Allowances: expatriation in range £280 to £308 per annum, cost of living in range £210 to £560 per annum. Passages for appointee, wife and children under 12 years. Part-furnished quarters at reasonable rent. Provident Fund Scheme.

Detailed applications (six copies), naming three referees by October 31, 1958, to Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1, from whom further particulars may be obtained.

METALLURGICAL RESEARCH

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(Industrial Group)

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SCIENTISTS

in its

RESEARCH & DEVELOPMENT LABORATORIES

(a) AT CULCHETH, WARRINGTON, LANCASHIRE

to join a team which advises on the choice of materials and the specification and approval of methods of construction of pressure vessels and ancillary equipment for use in nuclear reactors. Collaboration with Electricity and Inspection Authorities will be involved. (Ref. 2565).

A first- or second-class honours degree, or equivalent, together with extensive experience supported by adequate laboratory investigation, are essential.

Salary between

£1,460 to £2,080,

according to qualifications and experience.

Supporting staff are also required to assist in this work. (Ref. 2577). A higher school certificate, or equivalent, with mathematics or a science subject as principal subject, is essential, and higher qualifications would be an advantage. Good relevant experience is also required.

Salary between

£1,360 to £1,630,

according to qualifications and experience.

(b) ALSO AT CULCHETH

to devise and control experimental programmes on all aspects of steels for reactor pressure circuits. Interpretation of results on currently used steels and the development of improved steels and welding processes in conjunction with industry will form an important part of the work. (Ref. 2566).

A first- or second-class honours degree, or equivalent, together with considerable appropriate experience, is essential.

Salary between

£1,460 to £2,080,

according to qualifications and experience.

(c) AT SALWICK, PRESTON, LANCASHIRE

to be responsible for development work on the powder metallurgy of refractory metals and allied processes. (Ref. 2567).

An honours degree, or equivalent, in metallurgy, together with experience in powder metallurgical processes, is essential. A knowledge of the techniques and hazards associated with the handling of radioactive metals is desirable.

Salary for this post will be between

£1,300 to £1,740,

according to qualifications and experience.

Contributory Pension Scheme.

Housing or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting appropriate reference, to Recruitment Officer, U.K.A.E.A., I.G.H.Q., Risley, Warrington, Lancashire.

Closing Date: September 29, 1958.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY,

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CHAIR OF METALLURGY

The Governors of the Royal College of Scienc and Technology invite applications for the Chai of Metallurgy, which will become vacant on Apri 1, 1959, on the retirement of the present holde Professor R. Hay. The salary is on a scale £2,40 by £100 to £2,700. Forms of application and particulars of the appointment may be obtained fron the Secretary.

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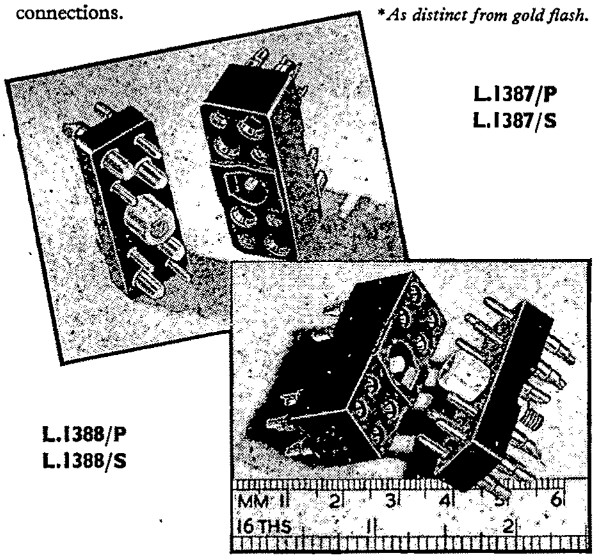

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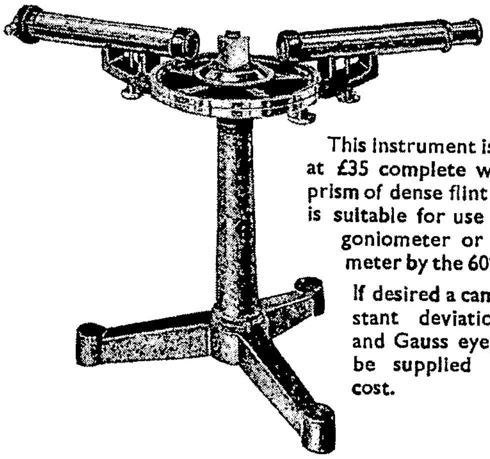

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POLICY, PURPOSE AND PARTNERSHIP IN EDUCATION

SIR WILLIS JACKSON'S presidential address to Section L (Education) of the British Association on the partnership between industry and education laid emphasis on the conception of partnership in the sense that industry and education should each interest itself in the work of the other and, where appropriate, contribute to the work of the other, as well as fulfil the responsibilities which directly accrued to it within its own domain. Industry's responsibility was analysed in some detail from both points of view; but, while Sir Willis did not discuss to any extent the specific parts to be played by the schools, the technical colleges and the universities, for example, his address had a much wider interest and directed attention to aspects of technical and technological education which, as some other addresses at the British Association meeting have indicated, are recognized as of increasing importance. Like so many others, he insisted that the supply of well-qualified and well-trained teachers is the most crucial aspect of all our educational plans; but the partnership he advocates is put in its proper perspective, so that the responsibilities of the government and of the community itself can no less clearly be seen.

Sir Willis considers that industry has already gone some way towards convincing the schools that industry can offer those with a sense of vocation as satisfying a career as the 'learned' professions, which have traditionally attracted a dominant proportion of the ablest young people of Britain. This means, he believes, that industry is coming to be seen not merely in terms of machines and scientific and technical processes, but also in terms of men of character and stature, and of the opportunities it provides both for the exercise of scientific and technical skill and for co-operation in service and human relations. None the less, he points out that the importance of the supporting contribution has been insufficiently recognized, and that we have given too little attention to the educational needs of the much larger body of technicians and craftsmen. Here, too, technical change is not simply altering the balance of the labour force and increasing the numerical importance of the scientific, technological and technical staff, of the skilled men engaged on service and maintenance, relative to direct labour. It demands also increasing versatility, adaptability and capacity for understanding changing situations and points of view.

To reach the consequent higher level of scientific knowledge and attainment in an increasing proportion of industrial personnel and extended and broader education for all, industry, Sir Willis suggested, carries a considerable responsibility, and he refers with appreciation to the value of the work of the Industrial Fund for the Advancement of Scientific Education in Schools. Nor is this the only point at which his address reinforces Prof. F. A. Vick's argument about the contribution of the university to education in a technological age. He commented, for example, on the desirability, in day-time release from employment, for some time in attendance at technical colleges to be available for participation in corporate life within the college and for the continuance of general education. Reinforcing the recommendation of the Committee on the Supply and Training of Teachers for Technical Colleges over which he presided, he urged the need for more industrial concerns to take active steps to promote close contact with full-time members of the college staffs and to increase the absolute contribution made by part-time teachers; in this connexion he touches on the importance of status and of associating some such teachers both with advanced teaching and with the formulation of academic policy.

Here, as when he referred to the importance of bringing representatives of the highest ranks of industry into closer association with the governing bodies and advising committees of the technical colleges, Sir Willis indicated ways in which we can more effectively deploy the full strength of our existing teaching strength, rather than increase its numerical strength. It could well be said that concern with obtaining the fullest value both from the present educational effort and the existing scientific and technical manpower in Britain was one of the keynotes of this address. That, for example, is the implication of Sir Willis's reference to the importance of supporting technicians and craftsmen and no less of his suggestion that sixth-form grammar school boys should not be encouraged to remain at school to the age of eighteen with engineering as their objective, if they have shown little aptitude for the traditional subjects of grammar school curricula. Unless boys are capable of undertaking advanced work in physics and mathematics with fair promise of success at Advanced Level of the General Certificate of Education, Sir Willis believes it to be far preferable for them to enter industry at an earlier age and pursue their studies within the technical colleges.

This engineer's conception of fitness for the purpose, of choosing the tool for the job which pervades the whole address, is one that is all-important if the nation is to obtain full value from its present educational effort—already some £740 million a year and, according to Sir Alexander Fleck, needing to be increased to some £1,200 million—and it supplies the decisive reason for attention to the apprenticeship system, the discussion of which occupied a large part of Sir Willis's address.

It is here that he regards the responsibility of industry as most direct, and he was highly critical of the failure of the Carr Committee to go further than to recommend a purely advisory national apprenticeship council, the function of which would be to keep representative organizations of employers and workers informed of progress and to collect and disseminate information about those aspects of training common to more than one industry. Something much more fundamental is urgently required, including considerable changes of attitude among both employers and trade unions, an extensive building programme and solution of a difficult staffing problem. The position is one that cannot be left to drift for, as once again we are reminded, the changing educational pattern means that from now on an increasing proportion of the boys of high natural ability who, in spite of deficiencies in their early training, have provided excellent craftsmen in the past, will remain at school beyond the age at which at present industry recruits its craft apprentices. A lowering in the quality of the entrants to craft apprenticeship is thus to be expected at a time when the raising, not lowering, of the standard of craft skill is imperative.

In this situation the deference of the Carr Committee to traditional practices and embedded prejudices on both sides could be disastrous, and such deference is the more disturbing in that Lady Gertrude Williams has already analysed the situation searchingly and constructively in her book "Recruitment to Skilled Trades". Sir Willis indicated the range of questions which her analysis has raised, but he declined to discuss them because he believes that individual opinion is unlikely to make any impact in the continued absence of a national body with executive powers and the financial means for exercising those powers effectively. Moreover, he pointed out that, so far back as 1944, the report of a conference of representatives of the Manchester and District Committees of the Engineering and Allied Employers National Federation, the Amalgamated Engineering Union, the major engineering institutions and the Regional Advisory Council for Technical and Other Forms of Further Education had recommended the establishment of a national engineering apprentice council as a central directing body, and of associated regional councils with defined responsibilities in their respective areas. These responsibilities for the organization and administration of training schemes included estimating the future needs of industry in the area and adjusting the intake of apprentices to training schemes accordingly; advising on the establishment, equipment, staffing and maintenance of apprentice training centres to meet the regional needs; co-operation with employers in placing apprentices on completing their courses; approval of facilities for further training; interest in the development of non-vocational interests; and the issue of certificates of competency on completion of apprenticeship. The report recognized the need for a detailed investigation as a basis for any such scheme, but equally the urgent need to face and solve the difficulties involved in implanting such proposals. It was confident then that it was within the power of Great Britain to ensure that its system of technical education, both in its teaching staff and in its buildings, was made adequate to the demands of the next decade.

A decade has been lost, but we need not be more pessimistic than in 1944 as to our ability to develop the necessary facilities if we are willing to apply the financial and other resources required, and resolute to deal firmly with whatever prejudices or obsolete practices obstruct such development. It means that the conditions laid down by Sir Willis Jackson must be faced frankly and resolutely handled as impartial inquiry and constructive thought may indicate. What duration of training, suitably organized and conducted, is really necessary for the different crafts, as against the universal five-year period from sixteen to twenty-one years of age for all crafts? Should the age of entry to craft apprenticeship be raised to permit the entry of boys who have pursued general education at school beyond the age of sixteen? Should early stages of training be carried out in training centres on a full-time basis where continued general education could also be provided, and if so whether such centres could be organized co-operatively by groups of firms on an adequate, nation-wide basis, or whether they must be provided by the local authorities? How to assess the numbers of recruits for the various crafts, and how to test competence—these are all questions demanding searching and impartial inquiry in the light of present conditions and trends, and resolute urgent action on the basis of such inquiry.

Finally, there is the question of finance. Whether a national fund should be provided jointly by the State, the local education authorities, employers and trades unions—and on what basis—demands inquiry, as does the question of how individual firms should be assisted to bear the cost of running their own training schemes. It can at least be predicted with confidence that whatever the basis to which such inquiry may point, it will offer a contribution to the economics of education out of all proportion to the direct expenditure involved. Running through the papers on varied aspects of education contributed to the Glasgow meeting of the British Association has been a note of concern that in the growing scale of expenditure on education, increasing care should be taken to see that the nation receives full value for that expenditure. Attention to this question of the training of technicians and apprentices will involve some further direct expenditure; but that expenditure is likely to be offset many times over by the elimination of the waste involved in the persistence of the present obsolete practices, quite apart from the direct gain in the more efficient and effective use of the more highly trained scientist and technologist whose work it is a primary function of the technicians and craftsmen to support and extend.

CHEMICALS AND CANCER

Mitotic Poisons and the Cancer Problem

By Dr. John J. Biesele. Pp. viii+214. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1958.) 37*s.* 6*d.*

A FEW years ago, the editors of "Tabulæ Biologicæ" asked cytologists and geneticists in various countries to provide material for quantitative tables on the effects of mitotic poisons and chemical mutagens. Several, possibly all, of those approached were of the opinion that the time for such a tabulation had not yet come in spite—or rather because—of a tremendous and bewildering wealth of data. While tabulation at this stage may do more harm than good by its false suggestion of orderliness and congruence in a field of much conflicting evidence, an impartial review was needed to summarize the present position and point out the most useful and promising lines for future experimentation.

Everyone interested in the subject of mitotic poisons—and this includes plant breeders and oncologists as well as cytologists, geneticists and biochemists—must be grateful to Dr. Biesele for having undertaken this task. The great number of literature references—nearly a thousand, including many German ones—shows what a tremendous mass of material has been compressed into less than 200 pages. It was not to be expected that this degree of condensation would result in an easily readable book, but there is no lack of clarity and precision. If, in spite of this, the facts are often confusing, this is not Dr. Biesele's fault. One only needs to look at the evidence for and against inhibition of deoxyribonucleic acid synthesis as the primary effect of alkylating agents, or at the description of the highly complex and variable interactions between purines to realize how far we are still removed from insight into the ways in which mitotic poisons act. It is natural that every group of investigators favours interpretations which agree with their own particular results, and thus conflicting theories have been built on conflicting facts. Dr. Biesele impartially reports both facts and theories and never falls into the error of facile over-simplification. A more personal point of view would almost certainly have made the book more readable, but it would probably have destroyed its prime value as an objective summary and source of references.

The only type of evidence which is almost wholly neglected is the purely genetical one. Like most cytologists, Dr. Biesele does not seem to recognize the fact that a genetically established chromosomal change is just as real as one seen under the microscope, probably more so. This bias has resulted in a somewhat incomplete report on the chromosomal effects of alkylating agents, and in the complete omission of formaldehyde as a substance which in *Drosophila* produces all known types of chromosome rearrangement. Incidentally, drosophilists would not agree that a chemical (3,6-disodium endohydrophthalate) which produced scarcely 1 per cent sex-linked lethals in *Drosophila* is "strongly mutagenic".

The data are grouped according to various types of mitotic effect: poisoning at prophase and interphase; poisoning of the chromosomes; poisoning at metaphase and later stages. Since these effects may overlap and many substances act in more than one way, a chemical classification might have been preferable; a good subject index, however, makes it easy to follow any particular substance or group of substances through the whole mitotic cycle. As indicated in the title, the importance of mitotic poisons in cancer therapy is stressed throughout the book. Dr. Biesele's own research on substances which act preferentially on tumour cells is here of special interest. The highly important role of mitotic poisons in cancer therapy, coupled with the fact that so far no really curative chemicals have been detected, adds great practical significance to this review.

C. Auerbach

NAPHTHALENE

The Chemistry and Technology of Naphthalene Compounds

By Norman Donaldson. Pp. xv+512. (London Edward Arnold (Publishers), Ltd., 1958.) 90*s.* net

THIS book is concerned with the preparation and manufacture of naphthalene derivatives, especially those, of course, involved in the manufacture of dyestuffs. Its most important feature can be illustrated by reference to the aminonaphtholdisulphonic acids: each of the thirty-six known isomers is listed together with at least an indication of its preparation, while the properties and manufacture of the more important, for example H-acid, are described in detail. The available information (industry broods over the more intimate) concerning such compounds seems to be assembled in this book, which, therefore, is valuable for reference purposes. Included also is discussion of the distribution of electrons in naphthalene and the mechanism of sulphonation, nitration, diazotization, diazo-coupling, the Bucherer reaction and other substitution processes. Unfortunately, these topics seem to place the author on unfamiliar ground, for there are comments of the type "However, negative substitution of amines also reduces their basicity, so that diazotisation velocity is decreased by the smaller proportion of amine salt available".

The book is not well written, the meaning of the text often being difficult to find. The difficulty is enhanced by the use of unexplained abbreviations, for example, E.s.d. in the table on p. 5 and the arrow which appears in the statement "Griess obtained the azo-dye aniline → naphthylamine in 1864" on p. 77, while its significance is explained on p. 85. The contents of the book have been assembled with insufficient attention to detail and there are more accidental mistakes than one expects to find in a book that costs 90*s*.

G. Baddeley

COLLOIDS, OLD AND NEW

Organic Colloids

By Prof. Bruno Jirgensons. Pp. xiv+655. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1958.) 85*s.*

IN this book of 655 pages the author attempts a complete survey of colloid science, with boundaries extending inside biological fields, with the object of producing a text suitable for non-specialists and readable by "students and research workers who have had basic courses in physics and organic chemistry". The emphasis is on "basic facts and relationships rather than on theory" and the treatment is essentially non-mathematical.

The author is at pains to fit modern macromolecular chemistry into the framework of classical colloid science, with the result that one occasionally encounters unusual combinations of old and new. There is a wealth of readable information in this book, necessarily without great detail, and the author has succeeded in saying something about almost every major topic in his field—in itself no small achievement.

Unfortunately, however, the text is marred by occasional inaccurate or misleading statements and by an apparently arbitrary selection on the part of the author of the material included. The following are a few examples. On p. 37 we read "The life span of a free radical in the process of polymerization is estimated of the order of a few seconds only"—a misleading statement without further qualification. The polymerization of γ-methyl-L-glutamate N-carbonic anhydride in the presence of pyridine is not necessarily initiated by traces of water as implied on p. 45. The phenomenon described on pp. 316–17 and cited as an example of "replica polymerization" has, in fact, no connexion with the latter (see Waltcher, *J. Polymer Sci.*, 14, 411; 1954). The section on synthetic polyamino acids (Chapter 25, section 4) is particularly inadequate. The chain-growth of polyaminoacids in the Leuchs reaction is said to be promoted by the presence of a polyamino-acid (the observation being attributed to Waley and Watson), with the suggestion that this is a further instance of replica polymerization. This is quite untrue; the preformed polymers used by Waley and Watson simply function as initiators (in the systems studied) by virtue of their terminal base groups, as stated clearly by these investigators; no mysterious "orientation effects" are involved. The α polypeptide of D-glutamic acid is not the capsular substance of *Bacillus anthracis* as might be inferred from p. 428. The important fact, mainly responsible for the recent rapid growth in interest in synthetic polypeptides, that these polymers can exist in crystalline α and β forms is not even mentioned. Finally, the uninitiated reader, looking at p. 474 and Figs. 125 and 126, will be left wondering whether silk fibroin is, after all, a β protein. Defects of this kind detract considerably from the value of the book as an introduction to macromolecular chemistry.

The first 16 chapters (comprising Part 1, 280 pages) deal with fundamental principles and general methods of preparation and study, while the remaining 18 chapters (Part 2) deal with selected groups of organic colloids. The scope of this part is illustrated by the following selection of chapter headings: Macromolecular hydrocarbons: Cross-linked space polymers; Cellulose and similar polysaccharides; Globular proteins; Nucleic acids, nucleo proteins and viruses; Colloid phenomena in cells and tissues; Colloid-chemical characterization of biocolloids in disease; Micellar detergents, dyes and pigments.

The book is well produced and misprints are few.

C. H. Bamford

VIRUS AND VEGETABLE

Investigation of Virus Diseases of Brassica Crops

By Dr. L. Broadbent. (Agricultural Research Council Report Series, No. 14.) Pp. vii+94+8 plates. (Cambridge: At the University Press, 1957.) 15*s*. net.

BRASSICA crops are susceptible to two virus diseases, cabbage black ringspot and cauliflower mosaic, which, periodically, have caused great loss to the industry. The years 1948–50 saw more than usually severe outbreaks in crops of cauliflower and broccoli. In 1950, Dr. Broadbent, with the collaboration of many members of the National Agricultural Advisory Service and others, began to expand work already in progress at Rothamsted Experimental Station with the view of learning more about these diseases, especially those aspects relating to their control. Work continued for the next five years, and in "Investigation of Virus Diseases of Brassica Crops" it is reported in detail.

The contents of the book may be divided into two main parts, one dealing with response to infection and the other with spread of virus. The first of these includes a study of the response of a wide range of hosts including many different varieties of cauliflower, cabbage, and other brassicas, and the effect of factors such as strain of virus, weather conditions and manuring on symptoms. It also includes a useful list of plants susceptible to each virus. The other part of the book deals first with the process of transmission of the viruses, including the relative importance of different species of aphids in the natural spread of the diseases and, secondly, with their spread into and within the seedbed and crop. Appended is a short account of the two viruses transmitted by flea-beetle causing turnip yellow mosaic and turnip crinkle.

The recommendations for control which emerge from the study are similar to those advocated in the past. However, the experimental scrutiny to which they have been put should enable them to be applied with greater confidence and effectiveness. It is heartening to learn that commercial varieties of cauliflower differed both in the readiness with which they became infected and in the severity of the symptoms displayed after infection. This encourages the hope that varieties with increased resistance or tolerance may be bred for use in the future.

The inclusion of a large amount of experimental detail tends to slow the reader, but this is largely off-set by good lay-out. The production and most of the plates are excellent. Combining as it does original observation and reference to the published work of others, it will be of great service to those requiring an up-to-date and full account of the virus diseases of brassicas.

J. H. Hitchborn

AN IMPORTANT HERBARIUM

The Sloane Herbarium

An Annotated List of the *Horti Sicci* composing it; with Biographical Accounts of the Principal Contributors, based on Records compiled by the late James Britten. Revised and Edited by J. E. Dandy. Pp. 246+2 plates+96 facsimiles of handwritings. (London: British Museum (Natural History), 1958.) 147*s*.

AMONG the historical collections at the British Museum (Natural History), the Sloane Herbarium is one of the most important. A few years ago the director, Dr. G. R. (now Sir Gavin) de Beer, published a biography of Sir Hans Sloane, under the title "Sir Hans Sloane and the British Museum" (published for the Trustees of the British Museum by the Oxford University Press, 1953). Sloane is rightly regarded as the founder of the British Museum and his herbarium is probably the most extensive accumulation of botanical specimens of the seventeenth and early eighteenth centuries extant or ever made. The dried specimens forming the *Horti Sicci* are in bound volumes (*H.S.* 1 to 334), many one to a volume, but some bound together in twos or threes, five not present, one (*H.S.* 334) in two volumes, and eight with extra numbers giving a total of 265 volumes.

The late James Britten, who for thirty-eight years was an assistant in the Department of Botany at South Kensington, prepared an account of the Sloane Herbarium, which was unfinished at the time of his death and was not published. This account made, it is that the figures on some of them are somewhat overcrowded, and the lettering is at times too faint.

An interesting outcome of the investigations is the light thrown on the provenance of the unlocalized specimens, named and figured by Audouin and Savigny, which were collected during Napoleon's invasion of Egypt. The close agreement between them and the Indonesian material indicates that they came most probably from the Red Sea coast rather than the Mediterranean.

There are a few nomenclatorial surprises in the work, such as the demonstration of the priority of *Margaretta* Gray over the well-known *Tubucellaria* d'Orbigny, and of *Dakaria* Jullien over *Watersipora* Neviani. The replacement of *Catenicella* auctt. by *Vittaticella* Maplestone may also be regretted but is correct. In three other instances, however, Harmer, always hitherto a stickler for the sanctity of the International Rules of Zoological Nomenclature, strays from the path of virtue—his substitution of the type species of *Celleporaria* Lamouroux and *Schismopora* MacGillivray by others cannot be accepted, and his statements on the taxonomy of *Hippoporella* Canu are open to serious question.

These are small blemishes, however, in a volume which completes a remarkable life-time's work on the Polyzoa. Harmer, of whom there is a striking portrait in this last volume, carried out his extensive studies with a scrupulous regard for scientific accuracy; he expressed his observations and conclusions with a clarity and fullness that make them easy to comprehend and use. In the result, his *Siboga* Reports rank as the finest contribution to our knowledge of the Polyzoa since G. Busk's classic *Challenger* Report in 1884.

Finally, we must refer to the parts played by Dr. Anna B. Hastings and Dr. L. F. de Beaufort (the editor of the reports) in the present publication. Harmer had mostly completed his work when the Second World War broke out, and the printing of the plates had already started in Holland in 1940. By the end of the War, Harmer's failing health had stopped his further work, and at his request Dr. Hastings was entrusted with seeing the report through the press. It must have been no easy task, as the typescript was not as ready for publication as had been supposed. Nevertheless, with her wide knowledge of the group, she was able to co-ordinate and frequently check the text. At the same time, she studiously avoided modifying Sir Sidney's observations and opinions: although she has made several pertinent comments, they are all clearly indicated. For all this, the zoological world owes a great debt to Dr. Hastings, as well as to Dr. de Beaufort, who wisely decided after the War to carry on with this important publication.

GEOLOGICAL NOTIONS OF BERNARD PALISSY

The Admirable Discourses of Bernard Palissy.

Translated by Aurèle La Rocque. Pp. x+264. (Urbana, Ill.: University of Illinois Press, 1957.) 5.50 dollars.

THE phenomena of the Earth's crust attracted attention long before the foundations of geology were laid at the beginning of the nineteenth century, but though pregnant with possibilities, the early observations had little effect upon contemporary thought and never came together as parts of a developing theme. Even to-day they are usually cited as novel notions anticipating present-day knowledge.

For this reason, an English translation of the "Admirable Discourses" of Bernard Palissy, a book that is neither readily accessible, nor easy to read in its sixteenth-century French, is very welcome because his work in ceramics and enamel is better known than his contributions to geological thought. It shows us the working of the mind of one who, had he lived two centuries later, would have contributed towards the emergence of geology as a science, and although the limitations of his knowledge sometimes led him to conclusions that we now know to be wrong, in those in which he was right he showed perspicacity beyond that of his contemporaries.

In a short introduction, the translator summarizes the little that is known about Palissy's early life, reviews his later activities against the political and religious background of his time, and appraises his contributions in the field to which the book relates.

Palissy spent much of his time at Saintes, north of Bordeaux, and although by no means uneducated, had little formal training; what he had did not include Latin and Greek so that his opinions were not greatly influenced by classical and medieval writers. For some years after 1575 he gave lectures on natural history in Paris, but his unorthodox scientific views, added to his adoption of the reformed religion, led to periods of persecution and his ultimate death in the Bastille.

The breadth of the field he made his own is indicated by the title of the book which embodied the material of his lectures—"Discours Admirables, de la nature des eaux et fonteines, tant naturelles qu'artificielle, des metaux, des sels et salines, des pierres, des terres, du feu, etc.". It is written in the form of a dialogue between 'Practice' and 'Theory'. Practice (himself) instructs Theory, who puts the questions or challenges the answers. When Theory called him a great dolt for doubting the philosophers who argued that the water of springs was provided by the sea, he replied that if that were the case spring water would be salty (which it is not) and the sea would have to rise as high as the highest springs (which it does not). "Don't you know," he continued, "that the land is full of holes, cracks and abysses through which the water coming from the sea would come out on the plains before it could climb the mountains? Now fetch your Latin philosophers to give me a contrary argument that would be as easy to grasp as the one I put forward."

He regarded springs as being supplied by rain water that had percolated down through sandy material until it reached an impervious bottom that could hold it up, and he was the first to give a correct explanation of artesian wells. He denied that fossils were relics of the Biblical flood, but thought them to be the remains of animals that had lived where the fossils are found, from which it followed that there had once been water where there was now dry land. His knowledge was not extensive enough to enable him to follow the argument to its logical conclusion and to suggest that land and sea had changed places, and he explained the phenomenon by postulating lakes that had drained away.

He recognized that rocks were not formed all at the same time, described an auger with a hollow tube at has now been revised and edited by Mr. J. Dandy, the present keeper of botany, and, with an introduction by Mr. Spencer Savage, formerly librarian and assistant secretary to the Linnean Society of London, is printed by order of the Trustees of the British Museum.

In a preface, Mr. Dandy modestly refers to the amount of revision he had to undertake on Britten's manuscript. This involved a page-by-page examination of all the volumes, many additions to and modifications of the original text, and modernization of botanical and other names. He emphasizes that the book is not a catalogue of the specimens in the Sloane Herbarium but a guide to its contents with historical information about the collectors. To taxonomists the type-specimens present in the Herbarium are of greatest importance and a complete list of these has not yet been prepared.

Mr. Savage revised and arranged the manuscripts left by James Britten, selected the facsimiles of handwritings, of which 96 are reproduced, and prepared an introduction. In this he gives some interesting generalizations regarding the collections that make up the Sloane Herbarium. Specimens were obtained from as many sources as possible with the aim of accumulating more new and rare ones than anyone else. No serious attempt was made to determine the plants taxonomically and there was so little arrangement that Linnaeus, who saw the Sloane Herbarium on his visit to England in 1736, wrote that it was 'in complete disorder'. Later there were attempts to refer the specimens to Ray's "Historia Plantarum" by Sloane himself and by Dr. Johann Amman, who became his curator. Since the Sloane Herbarium is made up of specimens from many collectors and previous owners the correct attribution of handwritings is of great importance, and Savage did good service in identifying many of these. Further notes regarding the Sloane collection are contained in the few pages of general talk by Britten.

The main bulk of the volume consists of two parts: an annotated list of the *Horti Sicci* composing the Sloane Herbarium and biographical accounts of contributors, together with some information about their specimens. Among the more important collections in the *Horti Sicci* are those of Sloane himself made in Jamaica and on the voyage thither (1687–89); those of Bartram, Catesby, Courten, Cuninghame, Kaempfer, Kamel, Kiggelaer, Petiver, Plukenet, and Vernon. There are many collections of British plants, including some first records for the British flora, and plants from gardens of which those of Philip Miller from the garden of the Apothecaries' Company at Chelsea are probably outstanding in taxonomic importance, and those from the garden of the Duchess of Beaufort, at Badminton, Gloucestershire, and from Boerhaave, Leyden, are of considerable horticultural interest. While the plant specimens are not listed the countries of origin of many of the collections are given.

The second part is an alphabetical list of those persons whose collections (first- or second-hand) make up the Sloane Herbarium together with longer or shorter accounts of their lives and of their contributions to the Herbarium. There is much useful and interesting information for the botanical historian here and numerous bibliographical references are given. The usefulness of the book is increased by an index to geographical localities and another to botanical names. The facsimiles of handwritings, mentioned above, are well reproduced as plates at the end of the volume.

W. B. TURRILL

THE *SIBOGA* POLYZOA

The Polyzoa of the *Siboga* Expedition

By the late Sir Sidney F. Harmer. Part 4: Cheilostomata Ascophora, II (Ascophora, except Reteporidæ, with additions to Part 2, Anasca). (Monographie, 28*d*, Uitkomsten op Zoologisch, Botanisch, Oceanographisch en Geologisch Gebied verzameld in Nederlandsch Oost-Indië 1899–1900 aan boord H.M. *Siboga*. Uitgegeven door Dr. Max Weber en Prof. Dr. L. F. de Beaufort.) Pp. xv+641–1147+plates 42–74. 240 guilders.

When Sir Sidney Harmer died in 1950 he had published since 1885 a long series of papers on the Polyzoa, including three reports (1915, 1926 and 1934) on the Polyzoa collected on the *Siboga* Expedition. The present volume, by far the largest of the reports, completes his studies on those extensive collections. Apart from three and a half pages, it deals with the Ascophora. Harmer had intended to divide these into two divisions, the Ascophora Imperfecta and the Ascophora Vera, based on the nature of the compensation-sac. The distinction is an important one, but, although his typescript explicitly referred a few families to the former, it was not clear (for reasons given below) whether all the remaining genera were to be included in the Ascophora Vera or only the majority of them. These 'remaining genera' are divided among thirty families, with eleven others unplaced. Altogether, species belonging to 84 Ascophoran genera are described, and numerous other genera discussed. The systematics and synonymies of the genera and species are dealt with fully.

As is usual with Harmer's work, the Polyzoa were not studied only from that point of view, however. Careful and detailed analyses of the morphology of the zoaria of a number of species are also given—an outstanding example is that of *Siphonicytara formosa* Harmer, and those of the species of *Conescharellina* are also noteworthy.

Previous to the *Siboga* Expedition, very little was known of the Polyzoa of the East Indies, and nothing of their deep-water representatives there. Now, Harmer's work has revealed a rich and varied Polyzoan fauna, collected from the shore-line down to abyssal depths, though the majority come from less than 90 metres. Some of the species have wide bathymetric ranges, for example, *Celleporaria tridenticulata* (Busk) was found at depths from 0–397 metres, and *Agalmatozoum decussis* (Canu and Bassler), previously recorded from 249 fathoms, was found at depths between 535 and about 3,000 metres.

As was to be expected, the East Indian Polyzoa show many similarities to those of the Philippines, although they include numerous species not described from the latter area by Canu and Bassler in 1929. In his comparisons, Harmer not only made full use of a collection of Philippine Polyzoa which those authors had sent to the British Museum (Natural History), but also of others, such as the Haddon Collection from Torres Straits and, more particularly, the Thornely Indian Ocean Collections. As a consequence, we now have full and easily usable synonymies and descriptions of the Polyzoa of the Red Sea and Indian Ocean. These are amplified by a wealth of clear and beautiful figures, such as characterize all Harmer's works, figures all drawn by the author himself. If any criticism of the plates can be the tip and handles of different lengths for bringing up samples of soil from various depths, and observed that crystals assumed characteristic angular forms, just as it was "given to plants to keep a certain order, as you see that roses and gooseberries form prickly spines for their defence".

The interest of the "Discourses" lies not only in their revelation of what Palissy noted and inferred, but as much in what he failed to realize by reason of the limitations of his own observations and his lack of knowledge of what others had discovered in the same field.

F. J. North

QUANTUM MECHANICS

The Principles of Quantum Mechanics

By Prof. P. A. M. Dirac. Fourth edition. (International Series of Monographs on Physics.) Pp. xii+312. (Oxford: Clarendon Press; London: Oxford University Press, 1958.) 35*s*. net.

THIS is the fourth edition of a work too well known to require reviewing in detail. Dirac's "Quantum Mechanics" must surely still have its place on the shelves and in the heart of every serious student of quantum theory. For as long as the reviewer can remember it has been part of the scheme of things—quantum theory absolute as first conceived by the author and as no one but he could set it forth. What other subject possesses a text-book which combines in this way such definitive character and yet such dissimilarity in form from all other treatises on the subject? Here is Dirac's "Quantum Mechanics" and there Pauli's "Handbuchartikel", scarcely recognizable as dealing with the same subject and, as it were, illustrating the principle of complementarity; the serious student could not do better than study them side by side, as was the reviewer's good fortune to do in his student days.

For the second and third editions the author rewrote much of the text, but in doing so, did not fundamentally change the spirit of the work, even when in the third edition he introduced the entirely new *bra* and *ket* notation. In this present edition the main body of the book has undergone almost no change, but the concluding chapters on relativistic quantum theory have been rewritten and altered very profoundly. Curiously enough the theory of the Dirac electron as expounded by Dirac and the developments following it have always seemed to the reviewer to be the least satisfactory parts of the earlier editions of this book. Just because the relativistic theory itself has not arrived at the same state of conclusiveness as the rest of quantum theory, the characteristic Dirac style is inevitably less satisfying when dealing with it. It has also been apparent for some time now that the treatment of the interaction of the electron with the electromagnetic field given in the third edition, far from being definitive, showed Dirac to be turning away from the main stream of current thought on the subject.

This has now been recognized by the author, who admits that "a quantum electrodynamics which demands conservation of the number of charged particles is . . . out of touch with physical reality". The extensive modifications made in consequence are most welcome (as is also the minor change to the more usual sign convention for the Hamiltonian and the α-matrices). The student of the new edition, instead of being ultimately deflected from the main stream of modern research, is now guided to a point where this stream is just within sight. However, he is not cast adrift in its turbulent waters. True to his principles to the last, the author stops short of all considerations which cannot be developed with full logical consistency. Renormalization, for example, is not even named and only the last half page makes reference to what occupies so many quantum physicists to-day: "People have succeeded in setting up certain workable rules", says the author, but in spite of the success of these rules in interpreting experiments, he refrains from discussing them, pointing out (with full justification) that they "do not fit in with the logical foundations of quantum mechanics", and leaving it at that.

At first reading one may regret the omission of so much important matter, but on reflexion would one not agree that this is as it should be? Dirac stands for perfection and where perfection is not yet possible, let others take over.

N. Kemmer

COMPRESSIBLE FLOW IN HIGH-SPEED AERODYNAMICS

High-Speed Aerodynamics (Compressible Flow)

By Prof. Elie Carafoli. Pp. 702. (London and New York: Pergamon Press, 1957.) 100s. net.

THE book is a translation of a Roumanian publication entitled "Aerodinamica Vitezelor Mari", edited by Editura Academiei R.P.R., Bucharest, and follows an earlier book on incompressible flow published by the same author. The latter has been translated into German and Russian but not, so far as I know, into English. In this book on compressible flow, Prof. Carafoli attempts to give a comprehensive account of subsonic and supersonic aerodynamics and in fact states in the preface, "we have endeavoured to deal with some present-day problems relating to compressible fluids both in their theoretical aspect and more particularly in their application to current problems of aviation".

While the author has gone a long way towards achieving this objective, he has not, in my opinion, been entirely successful. The book is mainly mathematical and contains much useful theoretical information on one- and two-dimensional flows of perfect fluids, but other aspects are given inadequate treatment, particularly those for which theory is not fully developed. In consequence the book lacks balance, and pays more attention to solved problems than to a discussion of those which are difficult to treat theoretically. For example, it contains little of practical value on methods of estimating wing loading in subsonic flow, whereas the corresponding problem in supersonic flow is dealt with at much greater length. Even so, attention in the latter case is mainly given to delta wings, for which mathematical solutions exist. No mention is made of Evvard's method, and the problem of estimating loading on wings of general plan form is not covered as adequately as it might have been. Hypersonic flow is not considered, and the book concludes with a section on unsteady flow theory which is no more than a brief and elementary introduction to the subject.

Progress in aerodynamic research is so rapid nowadays that a book which is up to date when written is inevitably much out of date, through no fault of the author, by the time it is printed and issued. Most of the few references in the present book refer to work that was done before 1954. Although the book is lacking in some respects, particularly in the practical application of theory, it could be read with profit by any student of aerodynamics who is mainly interested in the mathematical solution of compressible flow problems. From the general reader's point of view, however, it could be greatly improved by the inclusion of more experimental data for comparison with theory, and fuller discussion of problems that are not amenable to theoretical treatment. An author's and a subject index would also make it more useful for reference purposes. W. P. JONES

NUCLEAR THEORY

Shell Theory of the Nucleus

By Prof. Eugene Feenberg. Second printing. (Investigations in Physics, 3.) Pp. xi + 211. (Princeton, N. J.: Princeton University Press; London: Oxford University Press, 1955.) 4 dollars.

THIS volume is the third production of the Princeton University Series "Investigations in Physics". When it was first published in 1955, the covers were of paper and the style of print was that of typewritten stencils, both features suggesting that serious effort had been devoted to keeping the price to a minimum. The actual cost was rather less than thirty shillings, which was impressively low for a specialized American text.

A second printing has now been made without any change in textual content, style or price. (Even typewriting errors are reproduced.) Unfortunately, between the two printings, the book has suffered the usual fate of expositions on topics in the front-line of research, and has become dated. Even when the book first appeared, it could not be said to provide an adequate discussion of all important branches of the subject-matter. This is much more true now as a result of the publication of many new papers on nuclear shell theory in the past three years. The book is still a good guide to certain classical aspects of shell theory, but there are a roughly equal number of topics which are scarcely mentioned. In particular, there is little mention of the modification of the theory that has been made necessary by the discovery that many nuclei are not spherical but egg-shaped (the strong-coupling version of the unified model of Bohr and Mottelson). No space is given to the work of Brueckner and others on the problem of why the shell theory failed to explain nuclear binding energies. Most surprising of all, only very brief reference is made to the work of Inglis and Elliott on the intermediate coupling version of the theory, which results in some of the most convincing and detailed agreement with experiment. Preliminary reports on these items appeared in 1953 and a great amount of work has since been published. It is regrettable that the production of the Princeton Series, although admirable in many ways, apparently lacks the flexibility necessary to enable a dated text to be revised.

The book opens with a survey of the evidence for shell structure in the nucleus, then presents the single particle model, and follows this by successive chapters on the comparison of the model with electromagnetic moments, electromagnetic transitions (isomeric states), and beta transitions. The latter chapters contain tables of data which are not complete in view of recent results but give a fair picture of the situation. The last chapters give discussions of particular shell-theory configurations and of collective vibrations of nuclei. In several places, nuclei lighter than neon are discussed in terms of *j–j* coupling, although it is well established that this is a very poor approach to such nuclei.

A. M. LANE

TRANSISTORS

An Introduction to Transistor Circuits

By E. H. Cooke-Yarborough. Pp. xii + 154. (Edinburgh and London: Oliver and Boyd, Ltd.; New York: Interscience Publishers, Inc., 1957. Published in collaboration with the United Kingdom Atomic Energy Authority.) 15*s*. net.

An Introduction to Junction Transistor Theory

By Dr. R. D. Middlebrook. Pp. xxiv + 296. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 68*s*. net.

Transistor Circuit Engineering

Edited by Richard F. Shea. Pp. xx + 468. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1957.) 96*s*. net.

UNTIL recently, little of the vast amount of information published about transistors had come by way of books, with the result that many newcomers to the transistor field have found the going somewhat heavy. Now, it appears that the drought is being followed by a deluge and it is interesting to see how three of the recent books help to produce a more balanced literature.

All three books are primarily concerned with the application of transistors, although Middlebrook's should also appeal to the designers of transistors. Cooke-Yarborough and Middlebrook intend their books as introductions, each author choosing an approach which is based on his own interests and experience. Shea and his co-authors, on the other hand, set out to give detailed guidance to the design of a wide range of transistor circuits.

After describing, with commendable brevity, how it works, Cooke-Yarborough considers the transistor as a circuit element. He discusses its use in various circuits, in each case carefully explaining what the transistor does, an approach which will help the reader when later he has to solve his own transistor problems. In view of Cooke-Yarborough's earlier contributions, it is not surprising that non-linear circuits take pride of place. Despite this limitation, the book should still appeal to both students and practising engineers who are looking for a readable introduction to transistor circuits. Some may find the unusual symbolism irksome, but the clarity of Cooke-Yarborough's writing should more than enable them to find the capacity for forgiveness.

Middlebrook's main interest centres around the transistor as a linear amplifier. However, the first section of the book deals with transistor physics, both qualitatively and quantitatively. This is followed by a section on electrical characteristics, leading to the derivation of equivalent networks for transistors. Much of the third, and final, section is taken up with a particular equivalent network. Engineers who specialize in the design of transistor linear amplifiers will find in this book a thorough theoretical background to the transistors themselves. Many others, including the designers of transistors, will find this a

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useful book, in which the subject matter has been well planned and ably presented.

Shea's book covers most kinds of transistor circuits, and is in many respects an enlarged and more advanced version of another book which he edited a few years ago. Written by a team of specialists, it naturally contains a wealth of practical information. However, it is not always up to date, a weakness that is inherent in a reference book that covers a rapidly developing subject. Nevertheless, it will be welcomed by many practising engineers, particularly by those whose work covers the design of a wide range of circuits. In addition to detailed studies of circuits, it contains a chapter describing how some of these can be fitted together to produce a practical equipment.

Without doubt each book fulfils a need and helps to bring a fascinating subject within closer reach of electrical engineers. D. D. JONES

DETACHMENT RELINQUISHED

Personal Knowledge

Towards a Post-Critical Philosophy. By Prof. Michael Polanyi. Pp. xiv+428. (London: Routledge and Kegan Paul, Ltd., 1958.) 42*s*. net.

A CHARACTERISTIC feature of the contemporary approach to science is that, both as a discipline and as a substantial part of knowledge, it is objective, and basically impersonal. These features are commonly considered to be virtues. For some time, and in several quarters, doubts have been cast upon this view: now in this monumental work Prof. M. Polanyi adopts a position completely rejecting the whole ideal of scientific detachment. There must be such a thing as the conception of knowing, and it is just this which he sets out to modify. Indeed, his title, "Personal Knowledge", demands some reconciliation, otherwise the two words appear contradictory. For his machinery, the author turns to *Gestalt* psychology. It is true, as he says, that scientists have shied at the philosophical implications of the theory: for himself he embraces them, prepared for the consequences. Naturally, these are likely to be more far-reaching in the biological sciences than in the domain of physics and mathematics. Otherwise expressed, the urge to detachment has done more harm in the former sphere: in the latter, at any event in recent years, formal impersonality has become somewhat disregarded. The late E. S. Russell (whose name, by the way, does not figure in the excellent index) was something of a pioneer in his "Directiveness of Organic Activities", and reached much the same conclusion, but by rather different paths.

This use of the *Gestalt* concept is vital, for, as is common knowledge, its outstanding principle is that of integration. Otherwise, Prof. Polanyi would have found himself inhibited from achieving what is perhaps the summit of his endeavour, namely, to link all purposive awareness to value. Axiological frustration may well be one of the deepest ills of our epoch; here at least is a system of methodology capable of resolving the paradox of increasing power with diminishing faith. The fact is that nobody but the author could possibly have written this book, or anything like it. The passionate element in the very act of knowing is not something subordinate; it is of the essence of creative ability. With it goes the coupling—more and more demanded as our mental process deepens—between the sciences and the humanities, if man is not to flounder in a bog, largely of his own making. Meanwhile, it is perhaps as well to face the essential difference between science and technology. Both need originality, which is therefore not a discriminant. What the scientist does is to probe more deeply into the nature of things than other people: the technologist, however, is quick to see how phenomena can be turned to practical ends, which involves the assessment of a host of factors entirely irrelevant to the scholar as such.

Under the general heading of "Commitment", several matters are discussed which reveal the quality of the author's mind, and the grasp which he has obtained over his subject. In particular, one may note the high state of stress which accompanies the solution of a major problem. It is only possible to experience this if one believes that the question has an answer: in the event of success, there is rejoicing in discovery and more rejoicing in accepting it as true. This state of affairs is akin to the late Prof. E. A. Milne's "logical pressure", which he described as a kind of pre-condition for great discovery. (The immediate condition is slightly different, and contains certain historical and personal elements which together may produce simultaneous effects, or a near-miss, as the case may be.)

Over and above all this comes the struggle to gain agreement that something fundamentally new is both valid and intellectually coercive. An example would be the non-Euclidian geometries of Bolyai, Lobatschevski and Riemann. Again (pp. 308–9), we are reminded how great are the responsibilities of commitment when a judge decides a novel case within the framework of the existing law. Perhaps it is not wholly an accident that several high wranglers have achieved distinction on the Bench: men who have been through the rigours of mathematical manipulation, but who have not lost sight of the artistry of logical processes.

The relation between the axioms discovered by Gödel and logical inference machines has a direct bearing upon the current problems of automation in general. The crux of the matter would appear to be the extent to which the rules of any art can be specified. But any skill or connoisseurship, which is unspecifiable, cannot be fed into a machine. It looks as if it is just this class of human properties which forms the entire basis of Prof. Polanyi's thesis, namely those generated by the mind in its passionate search for truth. It is in this sense that "the powers of the mind exceed those of a logical inference machine".

Towards the end, the author introduces his concept of a heuristic field, with its analogues of lines of force, which "should stand for *an access to an opportunity*. . . ." It is significant that the greatest artists of the Italian rennaissance recognized this almost intuitively, when (as X-radiography has revealed) they made tentative outlines, perhaps with a blunt instrument, to the limbs of their figures before committing themselves to the final form. In the same way, Prof. Polanyi has spent some nine years in his majestic 'groping' for the ultimate verities, and thus shares in the wisdom of the ages "as one that traceth". F. I. G. RAWLINS

Veterinary Protozoology

By U. F. Richardson and Dr. S. B. Kendall. Second edition, revised. Pp. xii+260. (Edinburgh and London: Oliver and Boyd, Ltd., 1957.) 22*s.* 6*d.*

ALTHOUGH protozoal infections of domestic animals are of the greatest economic importance, especially in tropical and warm countries, there are scarcely any reliable English text-books of protozoology covering this field to which students and practitioners of veterinary medicine can turn for information. As the first edition of the book under review, written by the senior author some ten years ago, suffered from a number of defects, it was hoped that the second edition, now produced by the joint efforts of two authors, would be considerably improved. The results are, however, somewhat disappointing, and the presentation of the subject-matter is uneven.

The general morphology and cytology of the protozoa, as well as their physiology, host-parasite relations and classification, are dealt with rather briefly in an introductory chapter, which is followed by six chapters on the flagellates, among which the trypanosomes rightly occupy a prominent place. Here it may be noted that the definition of certain inner structures (blepharoplast, basal granule, parabasal body and kinetoplast)—here, and in the introduction—are contradictory and confusing. A short chapter on *Histomonas* and entamoebae is followed by four chapters on the Sporozoa (especially coccidia and piroplasms). These are adequately dealt with, but more space could have been given to toxoplasmosis. A special chapter is allocated to ciliates (*Balantidium*) and an assembly of protists of uncertain systematic status, followed by chapters on chemotherapy and techniques.

In all sections, the description of the pathogenic parasites and their life-history is accompanied by an account of the diseases caused by them, and their treatment. These form the most valuable part of the book, whereas the description of some of the species of protozoa is not sufficiently accurate or clear for their differentiation. Furthermore, the parasitological diagnosis of some infections would have been facilitated by the provision of more and better figures, and by reference to the existing ones in the text.

C. A. HOARE

Nuclear Radiation in Food and Agriculture

Edited by Prof. W. Ralph Singleton. (The Geneva Series on the Peaceful Uses of Atomic Energy.) Pp. xii+379. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 64*s.*

THIS book is one volume of a series being published to cover various parts of the Geneva Conference on the Peaceful Uses of Atomic Energy. The volume under review is devoted mainly to those portions of the Conference which are concerned with food and agriculture. Each chapter of the book is a paper from the Conference and has therefore already been published by Columbia Press in the Proceedings of the Conference.

The editor—Prof. Singleton—has selected 28 papers for this book, from nearly 100 which were on appropriate subjects. The ones he has chosen are either reviews, such as "Use of radioisotopes in soil and fertiliser studies" by A. L. Dean, or specialist papers on important topics such as "Genetic erradication of the Screw-worm fly" by Bushland *et al.* In this way the editor has produced a book which should appeal to a wide range of readers.

The majority of the papers in the book refer to work with plants rather than animals. This editorial choice was made because the papers involving animals were mainly physiological in nature, rather than of general agricultural interest. There is, however, a section of six chapters on genetical and biological hazards of radiation, some of which are mainly relevant to humans. These latter papers could have been omitted since they are not primarily of agricultural interest and can be found elsewhere. It might then have been possible to have included other more relevant papers. Nevertheless, the book covers much important work. There are eight main sections dealing with nuclear radiation in fields as diverse as the use of radioisotopes; photosynthesis; plant physiology, pathology and cytology; soils and fertilizers; crop improvement; food sterilization; in addition to the subjects already mentioned.

A further feature is a list of relevant papers including those which were not selected for publication in the book. This adds greatly to its value.

LORNA J. LILLY

National Libraries of the World

Their History, Administration and Public Services. By Dr. Arundell Esdaile. Second edition, completely revised by F. J. Hill. Pp. xv+413+12 plates. (London: Library Association, 1957.) 44*s.*

THE second edition of Dr. Esdaile's book describes some thirty-two of the national libraries of the world, the growth of their stocks and the development of their services and the effect of the Second World War. Admirably presented and produced, it is representative rather than comprehensive, and the selection has been determined by such considerations as fame, historical interest or administrative significance, and also with a view to geographical distribution. The British Commonwealth is represented by the British Museum and the National Library of Canada, with short notes on the National Library of Scotland and the National Library of Wales, the National Library of the Commonwealth of Australia, Canberra, the South African Public Library, Cape Town, and the State Library, Pretoria, and the United States of America by the library of Congress. That list also indicates the key importance of the notes on the place of each library in its national system, though even here a note on the British Museum which does no more than refer to the National Central Library can scarcely be regarded as adequate. The value of the book to a general reader and to many librarians would be enormously enhanced if these notes could be expanded to include a brief account of the several national systems and the way in which needs of those concerned with the varied fields of science and technology as well as of the arts and humanities are served.

R. BRIGHTMAN

Extinct and Vanishing Birds of the World

By James C. Greenway, Jr. (Special Publication No. 13.) Pp. x+518. (New York: American Committee for International Wild Life Protection, 1958.) 5 dollars.

DR. GREENWAY has performed a most estimable service in completing this scholarly and painstaking analysis.

The large-scale exploitation of the landscape of countries colonized by the modern European has made disastrous inroads into native faunas. The physical removal of great areas of habitat (for example, forests and swamps) and the ravages of introduced rats and cats have been responsible, more often than direct commercial exploitation, pest-control and 'sport', for the decimation of many kinds of animals.

Yet it is gratifying to see from Dr. Greenway's data that the picture is not yet as bleak as one might have thought. For example, the early British settlers freely ravaged the faunas of North America, Australia and New Zealand—yet only one Australian, one New Zealand and two North American 'full' species are known certainly to have disappeared, and only three more species are thought probably to have become extinct in those countries.

Of the thousands of species of modern birds, only 44 are known to have vanished, and a mere 12 probably have done so, although hundreds have become relatively rare and may be in danger. Of those that have gone, almost all were island forms. No less than 12 species—more than one-quarter of total extinctions—have disappeared from islands of the Central and Western Pacific alone. In certain cases at least, the chief factors responsible seem to be the impact of imported eutherians (particularly rats) on highly specialized island (often ground-nesting) natives.

The ecologist and evolutionist, as well as the conservationist, will find a great deal to interest him in this book; and Dr. Greenway is much to be congratulated on its production. A. J. Marshall

Georgia Birds

By Thomas D. Burleigh. Pp. xxx+746+48 plates. (Norman, Oklahoma: University of Oklahoma Press, 1958.) 12.50 dollars.

THIS large and handsome volume, published in co-operation with the U.S. Fish and Wildlife Service, is written and illustrated by men who have worked in the field in Georgia. It keeps commendably to the proper purpose of an area study, without attempting to be also a text-book or field-guide for local ornithologists. Thus, the main information for each species relates to its distribution or occurrence in the State, and to its habits as observable there, with a little background on general distribution and on recognition. There are contributed chapters on the history of ornithology in Georgia and on the physiography of the State. The fine colour-plates by G. M. Sutton depict characteristic species in their Georgian habitats; the photographs are primarily of environmental interest; and there are several distribution maps. Landsborough Thomson

British Herbaria

An Index to the Location of Herbaria of British Vascular Plants with Biographical Reference to Their Collectors. Compiled by D. H. Kent, with the assistance of E. B. Bangerter and J. E. Lousley. Pp. 101. (London: The Botanical Society of the British Isles, c/o Dept. of Botany, British Museum (Natural History), 1957.) 20*s*.

THE native British flora, so far as vascular plants are concerned, is relatively poor in number of species but is of particular interest from the geographical position of the British Isles on the north-western margin of Eurasia and because of the diverse ecological conditions within them. Many of the professional and amateur botanists who have studied British plants accumulated herbaria, and these are in many different institutions or in possession of individuals. To trace the whereabouts of some and to ascertain their value is not always easy, and the account compiled by Mr. D. H. Kent, with the assistance of others, will be useful to many who are making detailed researches on various aspects of the British flora. The list of universities, museums, and other institutions possessing herbaria of or with British plants is a long one. It is hoped that proper attention is given to the continued preservation of the specimens. The alphabetical index to collectors is "to indicate where material of individual collectors is represented, and often this is to be found in several herbaria". Obviously it is scarcely possible to compile a complete index of this kind and a great deal of dependence was placed on replies from those in charge of museums and other institutions. Useful information as to size of collections, dates of collectors, etc., is given under many of the names. There are, however, a great many gaps and it may be that the present publication will result in these being largely filled for a new edition. W. B. Turrill

Commutative Algebra

Vol. 1. By Prof. Oscar Zariski and Prof. Pierre Samuel, with the co-operation of I. S. Cohen. (The University Series in Higher Mathematics.) Pp. xi+329. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 52*s*. 6*d*.

THE present book makes its appearance after two decades of intensive research, in which the authors themselves have played a leading part. It will be of great value to graduate students and research workers who wish to specialize in this branch of mathematics, for it is the only connected account of the subject. After a chapter of basic definitions and concepts there is a polished account of the theory. This proceeds via field theory and the theory of ideals and modules to the properties of Noetherian rings. The ideal structure of such rings is thoroughly explored. The last chapter is concerned with Dedekind domains and classical ideal theory. Examples illustrating the theory are given in places. But the reader may find the account rather concentrated. If he asks why certain topics are introduced he will find no answer, for it is hidden in the geometric background to the whole theory and there is no hint of this except in the preface, where we are promised the motivation in the second volume. A surprising feature is the apparently complete lack of any references, either to other books or to original papers. It will be difficult for the reader to link the work with the related literature unless he is under expert guidance.

Commutative algebra began as a branch of abstract algebra in Germany and remained a child until the late thirties. Now it is a towering giant (hence this first of a two-volume work), existing in its own right. One questions whether the subject can expect to attain a position of near immortality, at the side of other branches of 'permanent' mathematics. It is true to say that it only grew because the parlous state of the theory of algebraic geometry seemed to point to the need for a new branch of algebra. Now we have it. But on the whole it has not yet done the job of work for which it was introduced. Nowhere in this first volume is there any indication of the motivation behind the development and the reader or prospective reader may, in looking for the purpose, be disappointed and close the book. It is to be hoped that the book has a better reception than this, but the reviewer has his doubts. L. S. Goddard

ROTATION OF ARTIFICIAL EARTH SATELLITES

By Prof. R. N. BRACEWELL and O. K. GARRIOTT

Radio Propagation Laboratory, Stanford University, California

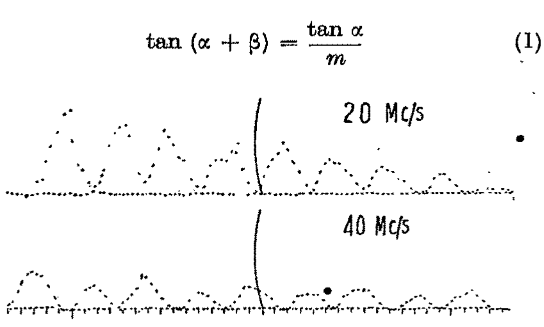
A MARKED feature of the signals received from *Sputnik* 1 was the deep, regular fading having a semi-period of about 4 sec. Because of the persistence of this effect from day to day, and because it occurred on both the 20 and the 40 Mc./s. transmission, it seemed likely to be due to free motion of the satellite about its centroid. Simultaneous records exhibiting agreement are shown in Fig. 1. It is true that such simple behaviour was not invariably recorded (Fig. 2); however, if different aerials, or combinations of aerials, were used at the different frequencies, then mechanical rotation of the satellite could modulate the two transmissions in different ways; and further complications could be introduced by the rapidly changing aspect of the satellite and by propagation phenomena. The modulation under discussion is probably ascribable to mechanical rotation, but in any case it is clear that deep fading is to be expected and that it is an embarrassment for telemetry, radio position finding and ionospheric investigations. For example, in Fig. 3, the more rapid fluctuations on 20 Mc./s. contain information about ionospheric ionization[1], but some of the useful detail is obscured by the deep motional fading; and in Fig. 2 the ionospheric phenomenon is entangled with motional effects.

Evidently it is important to know about the state of rotation of satellites, and here means will be considered whereby rotational effects may be eliminated. Fig. 4, which shows a recent field-strength record on *Sputnik* 3, suggests that the problem may already be solved.

Consider a pencil-shaped satellite, such as *Explorer* 1, which is launched in a state of rotation about its longitudinal axis. At the moment of *Brennschluss* of the final rocket of the final cluster, let the instantaneous axis of rotation make a small angle α with the axis of symmetry of the satellite. Then the angular momentum vector $\vec{h}$ will be coplanar with the axis of symmetry and the angular velocity vector $\vec{\omega}$, making an angle β with the latter (Fig. 5). The angle β will depend on I and J, the axial and transverse moments of inertia, as follows:

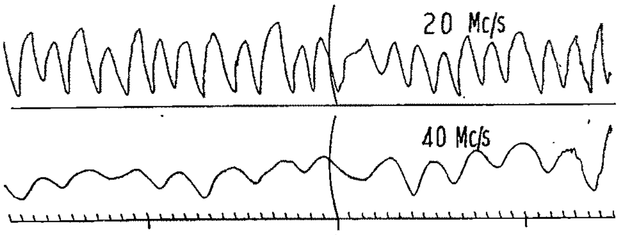
$$\tan(\alpha + \beta) = \frac{\tan \alpha}{m} \qquad (1)$$

where $m = I/J$. For a very long and thin satellite not spinning true ($\tan \alpha \gg m$), the angular momentum vector will be almost perpendicular to the rod. (That this is so is evident from the instantaneous motions of the nose and tail, perpendicular to the paper (Fig. 5), in opposite directions.) For example, launching a homogeneous cylinder 6 ft. long and 6 in. in diameter, only 2° off true, will displace the angular momentum 74°.



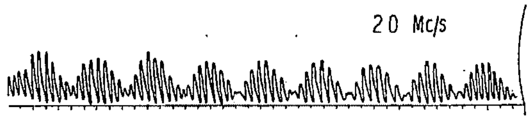
1957, October 8d. 06h. 50m. U.T.

Fig. 1. Simultaneous recordings of the signals received at 20 and 40 Mc./s. showing agreement indicative of satellite rotation. Recorded at Stanford, October 7, 1957, on horizontal dipoles. At this time the transmission was keyed. Time-marks in Figs. 1–4 are at 1-sec. intervals



1957, October 19d. 13h. 14m. U.T.

Fig. 2. Some anomalous observations on 20 and 40 Mc./s.



1957, October 9d. 15h. 13m. U.T.

Fig. 3. Rapid fluctuations associated with ionospheric ionization when the satellite passed over Stanford at great height

The ensuing force-free motion, or Poinsot motion, consists of an axial spin $n = \omega \sin \beta \operatorname{cosec}(\alpha + \beta)$ about the axis of symmetry superimposed on a slewing motion about the invariable line (the direction of total angular momentum) with an angular velocity $\Omega = \omega \sin \alpha \operatorname{cosec}(\alpha + \beta)$. To a rough approximation in the present special case:

$$n \simeq -\omega \cos \alpha$$

and

$$\Omega \simeq \omega \sin \alpha$$

This motion can be visualized as the rolling of a cone of semi-vertical angle α fixed to the satellite, on a fixed cone of semi-vertical angle β.

Thus, in addition to spinning with an angular velocity just below the rate imparted intentionally, the rod would execute a tumbling, waltzing or screwing motion, depending on the orientation of the invariable line to the direction of flight; and since this orientation changes it might waltz overhead at one place and proceed overhead like a propeller at another a quarter of a period later.

Undesirable as this is, both the rate at which it occurs, and the direction of the invariable line, may be set by accidental circumstances of launching not known in advance. It is now very interesting to draw a contrast with the much more favourable phenomena exhibited by a disk.

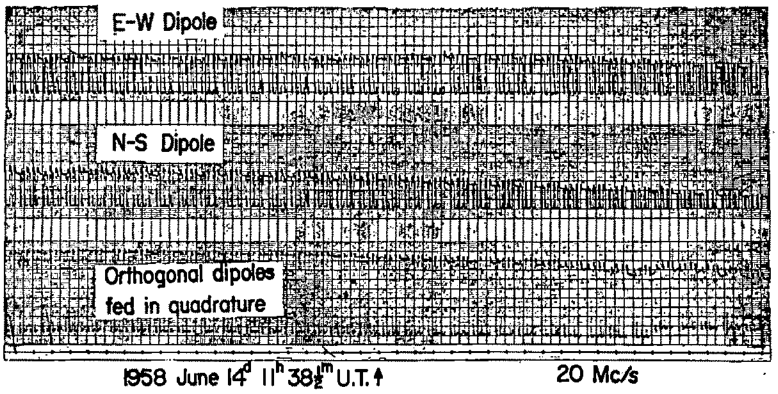


Fig. 4. Field strength record of *Sputnik* 3 which shows Morse-type modulation but which is free from pronounced rotational modulation, thus simplifying the study of interesting effects which shed light on the ionosphere

Let a disk be launched with an angular velocity $\vec{\omega}$ which by accident departs by an angle α from the axis of symmetry. Then the angular momentum $\vec{h}$ falls midway between this axis and $\vec{\omega}$, as may be deduced from equation (1) by putting $m \simeq 2$ (Fig. 6). The disk spins about its axis of symmetry with an angular velocity $n = (m - 1)\ \omega \cos \alpha$ and rocks about the invariable line with an angular velocity $\Omega = \omega \sin \alpha \operatorname{cosec} (\alpha + \beta)$, as before, but in this case the approximations for small α are:

$$n \simeq \omega \cos \alpha$$
$$\Omega \simeq 2\omega$$

Small errors thus produce small effects.

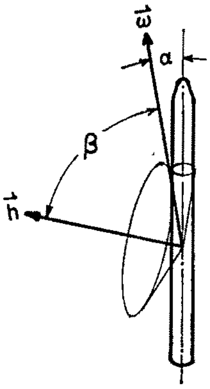


Fig. 5. Relationship of angular momentum $\vec{h}$ to a rod-shaped satellite

If a pair of transmitting dipoles, excited in quadrature, are placed orthogonally in the equatorial plane of a small satellite rotating precisely about its axis of symmetry (Fig. 7), clearly no modulation of signal level would be noticed at any place on the ground (other than small effects due to modification of the dipole radiation pattern by the satellite body). There would simply be a frequency shift equal to the number of revolutions per second. Such an antenna is therefore basically good for counteracting the effect of rotation on field strength and has been described in *Radio*[2]. If now the angle α is not quite zero, then in the case of a disk an observer not near the nulls of the radiation pattern will notice shallow amplitude modulation the rate of which is identifiable as twice the spin frequency. By contrast, the signal from the rod will be deeply modulated, at a rate not necessarily known in advance.

A disk-like satellite ($m \simeq 2$) thus has advantages. It is not necessary that the appearance should be disk-like, only that m be greater than 1. For example, *Sputnik* 3, a conical shell containing batteries fixed in its base[3], may well be disk-like as regards its moments of inertia.

Very interesting questions now arise as to whether the rocking or slewing motions may be suppressed, following the launching. Evidently, one way would be to operate suitable auxiliary rockets. Suppose, however, that the satellite contains viscous fluid or a vibration damper roughly tuned to the rocking frequency, which converts kinetic energy of rotation to heat. Then it can be seen, by bearing in mind the invariance of $\vec{h}$, that in the case of a disk the rocking will be damped out, and that the final angular velocity ω_2 will be given by

$$\omega_2 = \omega\left(\cos^2 \alpha + \frac{\sin^2 \alpha}{m^2}\right)^{\frac{1}{2}}$$

This will leave the angular momentum unchanged but will mean a loss of energy of $\frac{1}{2}J(1 - m^{-1})\ \omega^2 \sin^2\alpha$, or approximately half the energy associated with the rocking motion. In the case of a rod, the spin will be damped out, and the rod will be left slewing exactly in a plane with a final slewing velocity Ω which is unchanged:

$$\Omega = \omega \sin \alpha \operatorname{cosec} (\alpha + \beta) = \omega\ (\sin^2\alpha + m^2\cos^2\alpha)^{\frac{1}{2}}$$

which may be very different from ω. The loss of energy is $\frac{1}{2}\, I\, n^2/(1 - m)$, which is of the same order of magnitude as the spin energy. The possibility of stabilizing a disk by dissipation is another advantage in favour of this shape. Using a vibration damper of quality factor Q capable of storing one Nth of the

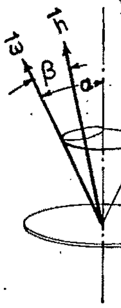


Fig. 6. Angular momentum and angular velocity of a disk-shaped satellite

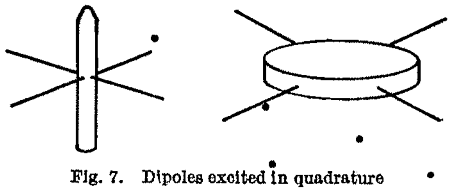


Fig. 7. Dipoles excited in quadrature

energy of the rocking motion, the damping time constant would be QN spin periods, which could readily be made a very small fraction indeed of a satellite's life.

This satisfactory result leaves only the question of also removing the spin rotation, which will, of course, be necessary in experiments requiring instruments to be pointed at celestial or terrestrial objects. Here it appears that the removal of angular momentum would suffice. For example, one might speed up an internal flywheel until the satellite body came to rest, and eject the flywheel together with all the angular momentum.

However, any method of increasing the moment of inertia about the axis of rotation would help. One might re-arrange the contents. Now it would not be necessary to reduce the satellite exactly to rest; for the purpose of observation from the ground one could accept a small rotation during the few minutes that the satellite was above the horizon of a given point, and the same applies to many celestial observations. By feeding out, under centrifugal force, a small mass in the form of a very long fine thread of strong material, the moment of inertia could be increased by a substantial factor and the spin velocity accordingly reduced.

The spontaneous observations of *Sputniks* 1 and 2 were participated in by D. Annett, K. C. Yeh and D. Pratt, members of the Radio Propagation Laboratory, Stanford University, under the direction of Prof. O. G. Villard, jun. Work on *Sputnik* 3 is supported by a grant from the U.S. National Committee of the International Geophysical Year. We are also indebted for stimulating discussion to participants in the Radio Propagation Seminar, which concentrated on satellites in the autumn and winter quarters, especially to Dr. A. T. Waterman, jun., and Mr. J. Fontana.

[1] Munro, G. H., and White, R. B., *Nature*, 181, 104 (1958).
[2] Vakhnin, V., *Radio*, No. 6, 14 (1957). Kazantsev, A., *Radio*, No. 6, 17 (1957).
[3] *Pravda*, May 18, 1958.

SIZE AND SHAPE CHANGES OF POLYELECTROLYTES: CONVERSION OF CHEMICAL INTO MECHANICAL ENERGY

CONTINUING earlier seminars[1] on polymer science in the Chemistry Department of University College, London, six lectures on size and shape changes of polyelectrolytes and on conversion of chemical into mechanical energy were given on April 14.

Prof. W. Kuhn (Basle) talked on the transformation of chemical energy into mechanical energy by high polymer systems made from vinyl alcohol and allyl alloxan, the alloxan component of which can be catalytically hydrogenated to a dialuric acid component. Slightly cross-linked filaments, containing this copolymer, swollen in dilute acetate buffer contract on hydrogenation and expand on oxidation, due to swelling and deswelling, produced by an increase of solubility in passing from the sodium salt of dialuric acid to alloxan. Thus, mechanical energy is produced from chemical energy arising from the oxidation-reduction process[2, 3]. In a previously described system, the chemical energy of neutralization had been transformed into mechanical energy with the use of filaments containing polyvinyl alcohol and polacrylic acid[4], dilation and contraction being brought about by pH changes. In these systems the length changes were accompanied by changes of the lateral dimension. A third system containing alternating layers A and B has been prepared, wherein length changes, exceeding 100 per cent, occur, without alteration of the fibre diameter[3]. A is prepared from heated cross-linked polyvinyl alcohol, and B is prepared from equal parts of polyvinyl alcohol and polacrylic acid also cross-linked by heating. The sandwiched layers A and B, moistened with polyvinyl alcohol, are dried, heated, brought into equilibrium with water and cut into strips. These contract and dilate respectively on the addition of acid and alkali; the cross-linked A-layers permit only a one-dimensional change of the B-layers and thus prevent a change of the lateral fibre dimension. In the dilated system the one-dimensional swelling of the B-layers is accompanied by optical birefringence. Swelling and birefringence disappear on the addition of acid. The volume change of these filaments during contraction or dilation is less than in the three-dimensional swelling and contraction; and the tensile strength of the filaments is maintained if the cross-section remains unaltered. The magnitude of the birefringence and the unidirectional swelling is in accordance with the requirements of the theory of polymer networks[5]. The stretching of the system involves a dilution of the B-layers owing to water uptake. An investigation of the Donnan-equilibrium between the interior of the B-layers and the outside shows that the stretching of the filaments produces an increase of pH in the outside medium. In the presence of a small quantity of sodium chloride the pH change is approximately proportional to the elongation of the B-layers. This pH change is such that the osmotic work required to stretch the B-layers chemically from L_1 to L_2 by increasing the degree of ionization from α_1 to α_2, and subsequently to return at constant lengths L_2 from α_2 to α_1, is equal to the mechanical energy required to stretch the B-layers mechanically at constant value α_1 from L_1 to L_2.

In the discussion, Prof. E. D. Hughes (London) asked whether the rate of the swelling and deswelling reactions is sufficiently large to make it feasible that processes of this kind are responsible for muscular activity. Prof. Kuhn replied that in his systems the rate appears to be diffusion controlled and depends on the fibre diameter. R. E. Cooper (London) referred to a paper by Hill[6], which shows that muscular activity can be so fast that diffusion from the surface of a fibre to its core cannot be rate-determining. If, however, in a twitch the outer region of the fibre were involved (for example, one half of the fibre diameter) then the rate of diffusion is fast enough to account for the observed rate of fibre contraction. In this connexion, Cooper referred to experiments[7] which showed that the length, the birefringence and the elasticity of fully swollen polyelectrolyte fibres can be markedly altered, at constant *p*H, by stoichiometrically well-defined cation exchange reactions.

Prof. J. A. V. Butler[7a] (London) gave a lecture on effects of salts on configuration of polyelectrolytes in which the electrolyte groups are ionized to a considerable extent. Two classes of linear polymers were considered : (*a*) those with flexible chains ; (*b*) those consisting of stiff chains. The configuration as deduced from their viscous behaviour in solution was discussed especially with reference to the effects of concentration and added salts. These polyelectrolytes are very sensitive to added ions, but there are marked differences, in that in (*a*) the effect of ions on the shape of the particle is the predominating factor, while with (*b*) the effect of added ions is principally on the interaction between particles. The behaviour of gels formed from these polyelectrolytes by the introduction of cross-links was discussed.

R. E. Cooper (London) lectured on polymerization of polyelectrolytes by magnesium ions[8]. Alginic acid (poly-*d*-mannuric acid) can be converted into water-soluble potassium, sodium and magnesium salts of well-defined stoichiometric composition. After special purification procedures the weight-average molecular weight of the potassium and sodium salt is below 3×10^5, while that of the magnesium salt is between 10^6 and 10^8. The hydrodynamic and other properties of these polyelectrolytes show that the increase of molecular weight does not give rise to a corresponding increase of molecular volume. It is concluded that the replacement of a monofunctional by a bifunctional counter ion gives rise, at constant *p*H, to a polymerization reaction in which a relatively small polyelectrolyte ion is converted into a larger, but much more compact, species. The effect is explained by the assumption that bivalent magnesium counter ions combine with the carboxyl and hydroxyl groups of the poly-acid to form inter- and intra-molecular bridges. The former are responsible for the large molecular weight, while the latter are responsible for the more compact configuration. Monovalent sodium or potassium counter ions, on the other hand, are not capable of producing cross-links.

In the discussion, Dr. H. Morawetz (Brooklyn) said that his work indicated the role of inter- and intra-molecular cross-links. In his systems molecular aggregation could be followed osmometrically, while group association was obtained from spectroscopy[9]. In studying the interactions with copper[10], the tendency of counter ions to associate with several groups attached to the same polymer could be clearly demonstrated.

According to Cooper and Wassermann[8], the properties of magnesium alginate depend on the sequence of operations in the preparation. Normally, the formation of magnesium chelates with carboxylic acids is rapidly reversible, and Cooper and Wassermann's results must be due to the co-operative effect of many complexes in a molecular aggregate. It has been observed that some polyvinyl chloride solutions attain their equilibrium state rather slowly ; and similar effects were noted by Boetger and Doty[11] in gelatine solutions.

Dr. H. E. Huxley (London) talked on structural changes during contraction of striated muscle[12]. The contractile material of striated muscle is composed of longitudinal protein filaments. There are two types of filament present, one type having a diameter (in frog and rabbit muscle) of about 100 A. and the other about 50 A. The thicker filaments are approximately $1 \cdot 5$ mμ long and contain actin. Filaments of each type are arranged in a succession of discrete arrays which overlap with arrays of the other type of filament, the two types of array occurring alternately along the length of the filaments and producing a band-pattern. During contraction and stretch the two arrays slide in or out of each other without any perceptible change in the length of the filaments of which they are composed. This seems to be brought about by cross-bridges between adjacent thin and thick filaments, and which correspond to the sites of actin myosin interaction. The cross-connexions occur at quite short intervals. The process by which chemical energy is transformed into mechanical work does not seem to be associated with appreciable changes in the length of the filaments.

Commenting on this lecture, Prof. W. T. Astbury (Leeds) referred to work[13,14] which shows that the X-ray diagram of dry skeletal muscle is effectively the sum of the diagrams of myosin and *F*-action ; and he pointed out that it is difficult at the moment to make the further desirable co-ordination with Huxley's electron microscope findings on what happens during contraction and stretch. Two other fine-structural lines of approach, however, are beginning to run together rather promisingly. In the first place, the concept of muscular contraction as a special manifestation, in myosin, of the property of supercontraction[15], and of the close association of the latter with the cross-β diagram[16], has lately been revitalized by the discovery of natural cross-β forms in bacterial flagella[14] and the egg-stalk of *Chrysopa*[17]. For these and other reasons[18], especially the configurational analogy between the polypeptide chains in the egg-stalk and basal pedestal of *Chrysopa* and the polyethylene chains in the astonishing crystals investigated by Keller[19], there can be little doubt now that the polypeptide chains in myosin, normally in the α-configuration, cannot merely be pulled out reversibly but can be contracted reversibly into a transversely folded configuration. In the second place, there is the recent demonstration by Doty and his collaborators[20] that the make-up of orthodox globular proteins, too, can consist in part of α-helices and that, moreover, the proportions of these can be reversibly varied to some extent. It follows in principle that there must be reversible changes in shape, when protein corpuscles form linear or other aggregates, with their neighbours. This provides the last decisive step in resolving the paradox between the long-range contractile fibre as a straightforward 'molecular yarn' and as a chain of corpuscles[18]. By virtue of these now established intra-corpuscular configurational changes, shortening of the latter can take place either directly or, more generally, by spiralization. Szent-Györgyi's discovery[21] that, by appropriate urea treatment, it is possible to dissociate myosin into small corpuscular units ('protomyosins') thus becomes not too difficult after all to reconcile with the classical X-ray point of view, and it is consistent also with the inference that bacterial flagella are of the nature of monomolecular muscles[14], and with the ultimate corpuscular construction of algal flagella[14], but unfortunately no approach along lines such as these seems compatible with Huxley's conclusions from electron microscope studies.

Dr. D. R. Wilkie[21a] (London) gave an account of the relationship between thermodynamics and the interpretation of muscle heat measurements. Active muscles produce a relatively large amount of heat, both during activity and during recovery; and the heat production is linked in some way to the mechanical change during contraction. Some of the chemical processes taking place in the muscle have been identified, and several of them are associated with large entropy changes. This introduces a serious uncertainty into the interpretation of the heat measurements.

C. A. Vernon (London) talked about the concept of phosphate bond energy[22]. The term 'high-energy phosphate bond' was first introduced by Lipmann[23] and had reference to the fact that the standard free energy of hydrolysis of adenosine triphosphate (ATP), which is said to possess a high-energy phosphate bond, is considerably higher than that of most simple orthophosphate esters.

Lipmann's concept has, however, led to considerable confusion and readily gives rise to pseudo-explanations concerning the role of adenosine triphosphate in biological processes. The quantities which provide the experimental basis for the high-energy phosphate bond concept are not bond energies, but standard free energy changes. As such they may may be used to calculate equilibrium constants, or to specify maximum work at unit activities. They do not provide explanations for the role of particular phosphate esters and are better not described by a highly misleading terminology.

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ARCHITECTURE OF A PROTEIN MOLECULE*

By Dr. J. C. KENDREW

NEARLY all the molecules most characteristic of living matter are very large ones, containing hundreds or thousands of atoms; proteins, fats, carbohydrates and nucleic acids are typical examples. Living organisms nearly always have well-defined size and morphology, and it is not surprising that they should be built up from units which are themselves large and complicated; furthermore, the subtlety of the chemical reactions carried out by cells demands a corresponding complexity in the molecules which mediate them.

Among these biological macromolecules the proteins are paramount. Some proteins are used as structural components, for example, the long filamentous protein molecules of bone, of tendon, of hair, of skin; others compose the muscle fibres which convert chemical energy derived from food into the mechanical energy of a moving limb. Another kind of protein molecule are the so-called enzymes, the essential catalysts which control the rate and determine the ordered sequence of the chemical reactions enabling each living cell to play its proper part in the complex economy of the organism, in a manner quite beyond the reach of the chemist in his laboratory. The enzymes are perhaps the most interesting of all types of protein, and they are members of the class known as globular proteins, so named because their molecules are nearly spherical.

Large molecules found in living organisms are generally built up by the combination of a great number of small molecules of a few standard types. For example, nucleic acid molecules are made of only four types of standard part—the nucleotides—arranged in linear sequence along a chain, the difference between individual nucleic acids residing in the difference of order of the units, just as the meaning of a message in the Morse code is conveyed by its sequence of dots and dashes. In proteins the standard parts are called amino-acids; and although hundreds or even thousands of amino-acids, arranged linearly in chains, may be contained in a single protein molecule, these amino-acids are of only twenty different kinds. In the proteins the analogy is to written language rather than to the Morse code; we may think that they differ in behaviour in consequence of their differing amino-acid sequences in much the same way as the meaning of a sentence depends on the order of the letters of which it is composed. Each kind of amino-acid consists of the same standard 'link' (the chemical group $NH_2.\overset{|}{CH}.COOH$) attached to a 'side-chain' characteristic of the particular amino-acid. When joined together the links form the so-called backbone (or main chain), from which project side-chains of twenty different kinds; the whole is called a polypeptide chain.

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* Based on an Evening Discourse delivered at the Royal Institution on May 21.

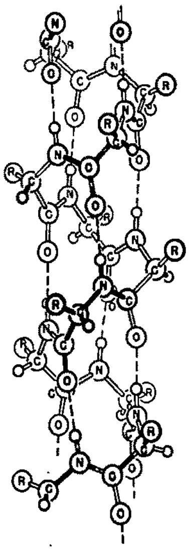

Fig. 1. The α-helix of Pauling and Corey. The side-chains of the amino-acids are all denoted by *R*

The actual sequence of the amino-acids in a protein was first determined by Sanger in the case of insulin. Sanger showed that every insulin molecule from a given species of animal contained the same fifty-one amino-acid residues arranged in the same order, and that the insulins of different species were nearly identical, differing by only one or two amino-acids in the whole molecule. In myoglobin, the protein which forms the subject of this article, there are more than 2,500 atoms, comprising 153 amino-acids linked together in a single chain. The amino-acid sequence of a protein is called its primary structure, and its determination for insulin was a great triumph of structural chemistry. But it is not the whole story: since the globular proteins are nearly spherical the amino-acid chains of which they are composed must be folded and re-folded like a ball of string. Furthermore, many proteins form very perfect crystals, which means that their molecules must be identical in shape as well as in amino-acid sequence, otherwise they could not pack together in the highly regular manner which a crystalline structure implies. We must therefore address ourselves to the question how the amino-acid chain in a protein is folded—for it is evident that the chemical behaviour of the complete molecule will depend on the spatial relationships of nearby amino-acids in the folded structure.

In 1951 Pauling and Corey showed that in some of the filamentous proteins of hair and skin and wool the polypeptide chain is arranged in the form of a regular helix, known as the α-helix (see Fig. 1); this is the so-called secondary structure of these proteins, and its presence is revealed by the X-ray pattern of the fibre, first studied in detail by Astbury in 1933. The α-helix has been shown to be present in many protein fibres, and there is suggestive evidence (though as yet no proof) that it also exists in globular protein molecules. By its nature, however, the α-helix is rigid and straight; a molecule made up of the 153 amino-acids in myoglobin, all in the form of a single α-helix, would be twenty times as long as it was wide, whereas, in fact, myoglobin is nearly spherical. It follows that there must be a yet higher category of fold—a tertiary structure—to bend the helix within the compass of a spherical molecule. Even this does not exhaust the complexities of protein molecules, for they often contain, in addition to amino-acids, some other type of chemical group, the so-called prosthetic group. Myoglobin contains such a group, a flat symmetrical arrangement of atoms with a single iron atom at its centre, known as the hæm group: it confers a red colour on myoglobin. When associated with the protein the hæm group has the property of combining reversibly with a molecule of oxygen; and indeed the function of myoglobin is to act as a temporary store of oxygen in the muscle cells, just as that of hæmoglobin (which also contains hæm groups) is to transport oxygen in the blood stream. Diving animals such as whales, seals and penguins need to store oxygen for long periods while they are under water, and accordingly contain large amounts of myoglobin so that their meat is very dark red; thus the studies of myoglobin about to be described were done with material derived from the sperm whale.

The only way of finding out the spatial arrangement of the atoms in a complex molecule is by studying the X-ray diffraction pattern of its crystals. The first structure so to be determined was that of sodium chloride. This molecule contains only two sorts of atom, and since 1913, when its structure was worked out by Sir Lawrence Bragg, the method has developed far, its most recent triumph being the determination of the complete structure of vitamin B_{12} by Dr. Dorothy Hodgkin. There are 93 atoms in vitamin B_{12} (excluding hydrogen, which is so light that its position cannot be found by ordinary X-ray methods); but even a small protein molecule like myoglobin contains more than ten times as many atoms as does the molecule of vitamin B_{12}, and it is simply beyond the scope of the method in its present state of development to contemplate determining the complete structure of a molecule as complicated as this, in the sense of discovering the exact relative positions of all its atoms. All that can at present be hoped for is to find out something about the general layout of the molecule—its tertiary structure, in fact.

One may regard each spot in the diffraction pattern of a crystal as corresponding to a train of waves running through the crystal. If all the waves are added together the result is a representation of the distribution of matter throughout the repeating unit (or unit cell) of the crystal, just as the wave-form of a musical note can be reconstituted by adding together the harmonics into which it may be analysed. If the waves are to be correctly combined, it is necessary to know four things about each: its direction, its wave-length, its amplitude, and its phase. The first three can be determined immediately by measuring the X-ray diffraction pattern; but the phase—the amount by which each wave is out of step with its neighbours—cannot be discovered directly by any physical method. This is the so-called phase problem of X-ray crystallography—if the phases could be found by direct measurement, X-ray structure determination would simply be hard work: as it is, cunning is needed as well as industry.

Simple structures have often been worked out by the trial-and-error method, which in essence consists in making intelligent guesses on the basis of previous knowledge about the molecule being studied. In proteins, however, the structure is too complicated for anyone to be able to make such guesses. Since the first X-ray pictures of protein crystals were taken by Bernal and Crowfoot in 1934, a large number of theories of protein structure has been based on them, but these were all speculative and, as it has turned out, much over-simplified. Speculation gave place to hard fact only as a result of the discovery, by Perutz in 1953, that it was possible to apply to protein crystals the so-called method of isomorphous replacement, which had often been applied to simpler structures, but which no one had, until then, shown could be used to study anything as complicated as a protein. The essence of this method is to add to each protein molecule in the crystal a single very heavy atom, such as mercury or gold; this has the effect of slightly changing the intensities of most of the spots in the diffraction pattern. It turns out that, by comparing the diffraction patterns of two crystals which differ only in the inclusion of the heavy atom in one of them, it is possible to solve the phase problem by an unambiguous procedure which does not involve guesswork.

Perutz applied this method to hæmoglobin, and by its use he was able to obtain a two-dimensional projection of the structure, as it were a silhouette of the molecule. This projection was derived by straightforward deductive methods, and it is certainly correct; but, unfortunately, the two-dimensional silhouette is so confused owing to overlapping that one can learn from it virtually nothing of the spatial arrangement of the atoms composing the molecule. In hæmoglobin one is actually 'looking through' the thickness of some forty atoms, so it is not surprising that the projection is uninterpretable. We subsequently applied the same method to myoglobin, the molecule of which is only one-quarter the size of hæmoglobin, and derived a similar two-dimensional projection which proved to be equally obscure.

It was clear that the only way to make progress was to extend the method to three dimensions. Such an extension is not easy, for several reasons. First, in order to get an unambiguous result in three dimensions it is necessary to compare the diffraction patterns of several crystals, each containing a heavy atom in a different place; secondly, the computations involved in determining the phase of each reflexion are more tedious than in two dimensions; and thirdly, for any desired resolving power it is necessary to examine far more reflexions.

In our recent studies on myoglobin we were able to attach four different heavy atoms at different places on the molecule, and to compare the diffraction patterns of each of the resulting substituted crystals with that of the protein alone. As to resolving power, the number of reflexions which must be included in the calculations in three dimensions is proportional to the cube of the resolution desired. Individual atoms are 1–2 Ångström units apart, and to see them separately would demand a resolution of at least 1·5 A., involving the measurement of more than 20,000 reflexions per crystal. Our plan was to try out the method, and to gain a first look at the structure, at low resolution. We chose the figure of 6 A., because at this resolution one might expect to see the polypeptide chains if they were in some compact configuration such as the α-helix: to attain this resolution it is only necessary to study 400 reflexions from each crystal.

The work of measuring these reflexions for crystals of myoglobin and of each of five different substituted myoglobins was carried out in the Medical Research Council Unit for Molecular Biology at the Cavendish Laboratory, Cambridge, and at the Davy Faraday Laboratory of the Royal Institution, in collaboration with Drs. Bluhm, Bodo, Dintzis, Phillips, Wyckoff and Miss Mary Pinkerton. After completing the calculations needed to determine the phases of all the four hundred reflexions, we computed an electron density map on the electronic computer EDSAC at Cambridge; this calculation was checked by Dr. Rollett, who repeated the computation on DEUCE at the National Physical Laboratory. The result was plotted in the form of sixteen sections through the unit cell, piled up (like the serial sections of organs used by anatomists) to give a three-dimensional representation of the density of matter throughout the unit cell, the density at each point being represented by contours (Fig. 2).

It was gratifying to discover that in the resulting three-dimensional synthesis there were indeed numerous rod-like features of just the dimensions and density to be expected of polypeptide chains arranged in a helical configuration. It is not easy to see these rods except by looking at the synthesis itself, but some of them are visible in the right-hand half of Fig. 2. There is little doubt that these rods are actually blurred representations of the polypeptide chains, and by adding up all the visible lengths of rod we can account for some two-thirds of the whole molecule.

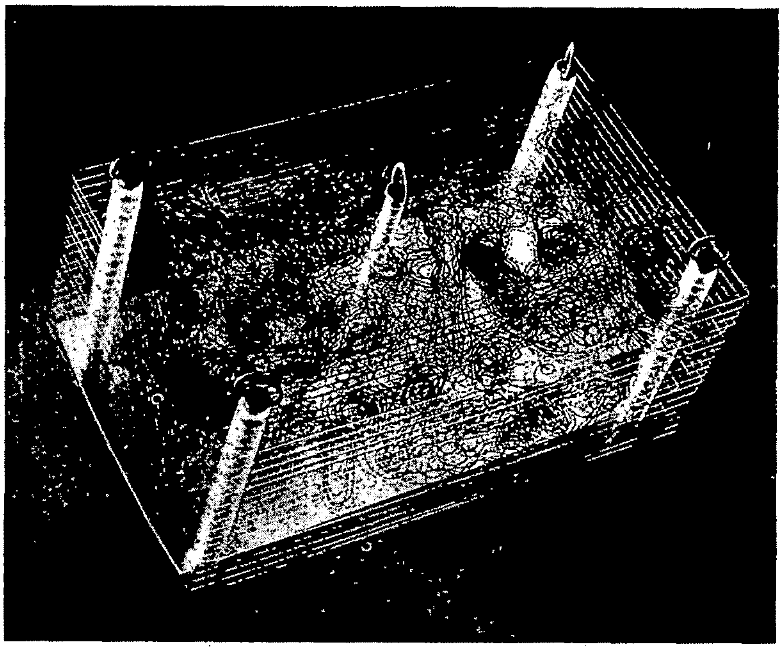

Fig. 2. Photograph of the three-dimensional electron density map of the unit cell of myoglobin. Two polypeptide chains can be seen on the right: the dense peak between them is the hæm group

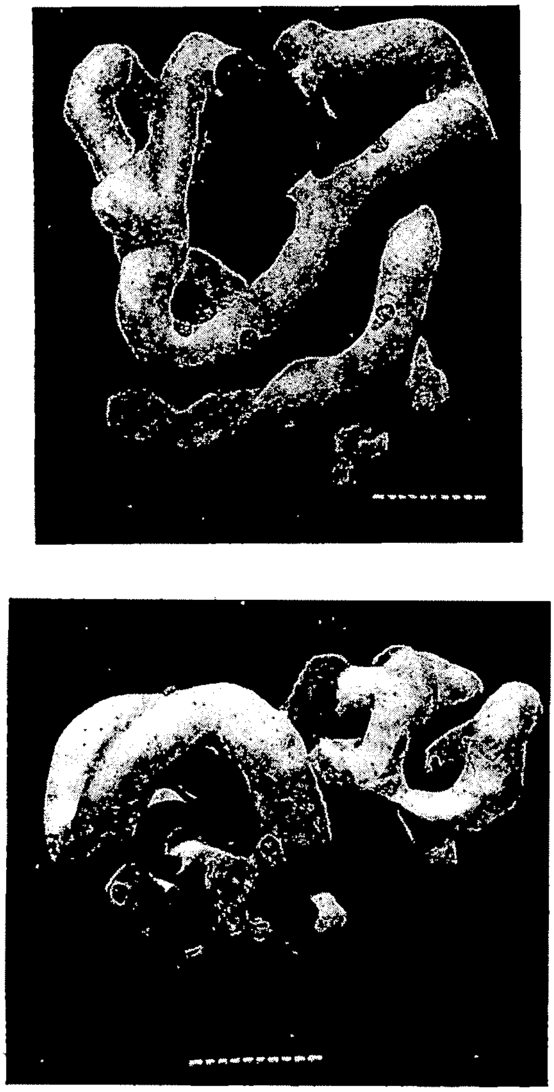

Fig. 3. Photographs of a model of the myoglobin molecule. The marks on the scale are 1 A. apart. The grey disk is the hæm group; the pair of small spheres attached to it is an oxygen molecule on the same scale. The larger spheres are heavy atoms used to solve the crystal structure

Another prominent feature of the synthesis is a flattened disk-like region the density of which exceeds the mean by some 50 per cent more than does that of any other part of the map. We think that this region is the hæm group itself, the high density being contributed by its central iron atom, the heaviest atom in the myoglobin molecule. The identification is confirmed by the orientation of the disk relative to the axes of the unit cell, which corresponds with the hæm group orientation deduced from a study of the optical and magnetic properties of the crystal; and also by the fact that one of the heavy atoms we were able to attach to myoglobin, the iodine atom in *p*-iodophenylhydroxylamine, which is known to be a specific reagent for the hæm group itself, has been located in the immediate neighbourhood of the disk.

The unit cell of myoglobin actually contains two molecules of protein, related by a symmetry axis (a screw dyad), and the electron density map likewise contains two molecules, each with its own hæm group and polypeptide chains. Furthermore, the two molecules in a single unit cell are closely surrounded by the molecules of neighbouring unit cells. To get an idea of the structure of a single myoglobin molecule one must, as it were, dissect out a single molecule from its neighbours. To do this, we make use of the fact that a protein crystal generally contains up to 50 per cent of liquid, which fills up the interstices between the protein molecules. In the electron density map we can recognize these interstices, because the liquid is featureless and has uniform electron density. Once the interstices have been located, the boundaries of a single molecule can be outlined in a straightforward manner.

Fig. 3 shows two photographs of a model of the single molecule thus separated from its neighbours. The sinuous white rods are the backbone of the polypeptide chain: it must be remembered that in reality these backbones are clothed with a layer of side-chains (invisible at this resolution) so thick that each polypeptide chain is in contact with its neighbours. Also marked is the hæm group, a flat grey disk; and on it are two spheres which represent an oxygen molecule and which have been included to convey some idea of the scale of the model, although, of course, they cannot actually be seen in the electron density map. The model also shows some of the heavy atoms which were attached to the molecule in order to solve the phase problem.

Chemical evidence indicates that myoglobin consists of just one single polypeptide chain, made up of 153 amino-acid residues. In the model this chain pursues a complicated winding path throughout the molecule, which has overall dimensions about 43 × 35 × 25 A. It may be asked whether it is possible to trace the course of the chain unambiguously through the molecule: in most places this can be done, but in some, for example, where it turns through a particularly sharp corner, the chain fades out at the resolution used in this map, and one cannot be sure of its course. It is clear that whenever the chain turns a corner it must lose its helical configuration for, as has already been pointed out, an arrangement such as the α-helix is essentially straight and cannot bend without ceasing in effect to be a helix at all: at the resolution of 6 A. an extended polypeptide chain would scarcely be visible. Measurement of the total length of chain in the model suggests that it is a helix for some 70 per cent of its length, a proportion which agrees well with estimates based on other techniques.

All in all, the model poses more questions than it answers. It gives us a first glimpse of the configuration of a protein molecule, but it is a tantalizing glimpse because the picture is so blurred that one cannot recognize side-chains, nor be certain how the backbone is folded—even whether it is a helix at all—nor know how the hæm group is attached to the rest of the molecule. Many of these questions could be cleared up if an electron density map could be drawn at higher resolution, even if that resolution stopped short of separating individual atoms. There seems no reason in principle why the resolution should not be improved, although an extension to atomic resolution is at the moment beyond our reach. At present, data are being collected for the 10,000 reflexions out to 2 A., and we hope that the electron density map prepared from these will in due course show us some of the finer details of the structure.

NEWS and VIEWS

Ministry of Supply : Scientific Research (Electronics and Guided Weapons) : Dr. E. V. D. Glazier

Dr. E. V. D. Glazier, who holds the post of director of Scientific Research (Electronics and Guided Weapons) in the Ministry of Supply, has been promoted to the rank of deputy chief scientific officer. Dr. Glazier, who was born in 1912, had his early training in general electrical and mechanical engineering in industry, joining the Engineer in Chief's Office of the General Post Office in 1933, when for the ensuing nine years he was engaged on the development of telephone systems. He graduated in the University of London and was awarded the degree of Ph.D. In 1942, he transferred under war-time arrangements to the Signals Research and Development Establishment, joining the Line Communication Group where he was responsible for the development of a wide range of signals equipment for the Army. He became head of the Line Communication Group in 1946, having in the interim spent two years in the Ministry of Supply headquarters. In 1950, he was transferred to lead the Research Division at Signals Research and Development Establishment and under his leadership the research group there made significant advances in a number of radio and electronic systems for Army use. In 1957, he returned to headquarters so that his practical training and research knowledge could be employed in advising on and co-ordinating the present and future research in electronics in the Ministry of Supply as a whole. Dr. Glazier is the secretary of the Radar and Signals Board of the Scientific Advisory Council. He is one of a band of people who, having moved progressively from application to research, are of very great value in the senior ranks of the Ministry of Supply.

Ministry of Supply : Electronics Research and Development : Dr. J. S. McPetrie

Dr. J. S. McPetrie has been appointed director general of Electronics Research and Development in succession to Dr. D. H. Black (see *Nature*, 182, 225 ; 1958). Dr. McPetrie has had a long and distinguished careeer in radio research. He joined the Radio Research Station of the National Physical Laboratory from the University of Aberdeen, and was engaged on early research on aerials and propagation at very high frequencies. He also explored methods of generating the progressively shorter wave-lengths required for this work. He was the author of several early papers on the properties of metric waves. During the Second World War he joined the Ministry of Supply and was lent to the British Commonwealth Scientific Office in Washington. At the end of the War he returned to take charge of the newly formed Research Division at the Signals Research and Development Establishment, Christchurch, where he was responsible for a wide range of research problems in radio and electronics for the Army. In 1950, he was promoted to be in charge of the Radio Department at the Royal Aircraft Establishment, where he was responsible for research and development in aircraft radio and navigational systems.

Dr. McPetrie has been a leading member of the Institution of Electrical Engineers for more than 25 years, and he was honoured recently by election as chairman of the Radio Section for the session 1957–58. His year of office was notable for the number of highly successful meetings and international conferences that were organized. In his new appointment Dr. McPetrie will be responsible for research and development in communications and radar for the Naval Air Branch, Army and the Royal Air Force, and for many of the other fields in which electronic devices are contributing to defence and civil aviation.

British Scientific Attaché in Moscow

The Department of Scientific and Industrial Research has announced that a senior principal scientific officer is to be appointed scientific attaché to the British Embassy in Moscow (see *Nature*, 182, 292 ; 1958). There are at present only four British scientific attachés, namely those attached to H.M. Embassies at Washington, Paris and Bonn, with one scientific attaché attached to the Embassies at Stockholm, Oslo and Copenhagen, and working between them. Their duties include reporting on scientific developments in the countries in which they serve and advising the ambassador on scientific questions.

Science Laboratories in Schools

A table circulated by the Parliamentary Secretary to the Ministry of Education, in reply to a question regarding part-time day release in industry, shows that the percentage of boys under eighteen released to attend part-time day classes in 1956–57 has risen to 33·8 (from 27 per cent) and of girls to 8·5 (from 7 per cent). On July 24 Sir Edward Boyle gave the estimated capital cost of new science laboratories started in 1957–58 at schools maintained by local education authorities as £1,100,000 and of those due to start in 1958–59 as £2 million ; of these figures £350,000 and £550,000, respectively, were at grammar schools ; £600,000 and £1,200,000 at modern schools ; and £150,000 and £250,000 at technical secondary schools. Questioned further on July 31, Sir Edward said that extensions to science accommodation at more than 100 grammar schools had been approved for the 1958–59 and 1959–60 building programmes. Although a recent survey reported in the *School Science Review* indicated that less than 10 per cent of maintained grammar schools had reported adequate science laboratories, 44 per cent of the schools had science accommodation conforming with the suggestion made in the Ministry's building bulletin.

Préhistoire Spéléologie Ariègeoises

The activities of the Société Préhistorique de l'Ariège are not as well known as they should be. The first bulletin for 1946 appeared in 1948 and the present one under review is No. 12 (pp. 152+7 planches. Tarascon-sur-Ariège : M. Romain Robert, Place Jean-Jaurès, 1957). One of the better accounts of the great painted cave of Niaux from the pen of Abbé Breuil will be found in No. 5. Each number has been full of interesting articles. The present number is no exception, and it contains many good papers : the rhinoceros and the cave bear as depicted in upper palæolithic art ; aurignacian art in central Europe ; notes on the Neolithic finds in the Department of the Aude ; several shorter accounts of various activities of the Society. Publications by local societies tend to be overlooked and are not always easy to obtain. But prehistorians would be wise to keep in mind the activities of this flourishing society in the Ariège and their energetic president, Monsieur Robert.

Journal of the Institute of Wood Science

In 1957 the Institute of Wood Science was inaugurated for the advancement of timber research and technology, and the first number of the Society's journal has now been published (*Journal of the Institute of Wood Science*, No. 1, March 1958. Pp. i+64. 15*s*.). Its scope is to include original papers, both in research and in technology, and reports of lectures and discussions at the Society's meetings. Research on timber is a very wide subject and involves many scientific disciplines, biological, physical, chemical and engineering, and the new journal should have a varied and interesting range of papers to publish. This is reflected in the first number, the contents of which includes such diverse subjects as variations in structure occurring during growth, the physiology of cambial activity, ultrasonic-pulse technique in investigations of strength, and the acidity of wood. All, as would be expected, have practical application in view, so that the journal should have appeal both for scientific and technological workers alike.

A New Estonian Natural History Journal

The Academy of Sciences of the Estonian Soviet Socialist Republic has produced a new journal of science, *Eesti Loodus* (Estonian Nature). Published bi-monthly, the articles are written in Estonian; but each issue contains abstracts in the English language which have been prepared by a translator with a remarkable flair for the right word and phrase. The articles cover a wide range of subjects including such topics as the artificial earth satellite; cliffs of the Jaagarahu Strata; Virginia witch-hazel in the Estonian S.S.R.; insects on snow; the practical application of the infra-red quenching of luminescence; the dependence of the external form of tetracorals on environmental conditions; the distribution of steppe plants and phytogeographical boundaries in Estonia; the 'Snowman'; ball lightning; the Elva Sandr, its formation and early hydrography; plant parasitic nematodes in Estonia and the protection of inanimate nature in the Estonian S.S.R. Each number also contains a section giving details of outstanding scientific discoveries as well as popular sections for young people and general readers. The editorial office is 5 Hariduse Street, Tartu, Estonian S.S.R.

The Geological Museum

The Geological Museum at South Kensington has just issued an attractive short guide to the exhibits (pp. ii+32. London: H.M. Stationery Office, 1958. 1*s*. 6*d*.). The publication is intended primarily for the visitor who wishes to make a short tour of the Museum and obtain a general idea of the scope of the display collections. At the outset is given a short history of the Museum and a sketch plan of the general arrangement. The three floors are then described in more detail again, with plans of particular sections. The general arrangement of the guide thus conforms with previous editions. The format is good and pleasing, though it is unfortunate that the method of reproduction of the photographic illustrations scarcely does justice to the originals.

The Wild-Fowl Trust

Besides a wealth of characteristic sketches by the Director, the ninth annual report of the Wild-Fowl Trust contains a remarkable collection of photographs of wild-fowl taken by some of the world's best natural history photographers (edited by Peter Scott and Hugh Boyd. London: Country Life Limited, 1958. 10*s*. net). Then there is a series of articles by members of the staff and friends of the Trust which not only records developments and researches at Slimbridge but also describes wildfowl collections and investigations in many other parts of the world. Probably the biggest event in the life of the Trust during 1956–57 was the opening of the Peakirk Waterfowl Gardens by H.R.H. the Duke of Gloucester on April 12, 1957. One of the main objects of this scheme is to provide sufficient funds to enable the Trust to take on the lease and maintenance of Borough Fen Decoy, which has been operated by members of the Williams family since its construction in about 1640. It is also of great value to have a place which can be used as a reservoir for birds, and an alternative collection, as the danger of epidemics among the birds at Slimbridge cannot be entirely dismissed.

During the period popular interest in the collection at Slimbridge continued to grow in a gratifying way. The total number of visitors in the calendar year 1956 was about 120,000. In 1957 this figure was reached before the end of August. Membership stood at 5,094 in January 1957—another record figure. The collections at Slimbridge and Peakirk now contain about 1,747 birds of 148 forms (116 species). In 1957, 770 young birds, of 72 forms, were reared in the collection. Extensive studies have begun in two fields new to the Trust's research programme: a systematic investigation into the food of wild fowl and the use of aircraft in surveys of the distribution and number of wildfowl.

Demonstration Meeting on Biological Acoustics

During the fifteenth International Congress of Zoology, held in London during July 16–23, the Committee for Biological Acoustics organized a demonstration meeting to illustrate the wide range of research in this comparatively new and expanding field. The meeting, held on July 21 in the Imperial College of Science and Technology, London, was open to all members of the Congress and attracted more than one hundred visitors. Work on the reception of human speech was shown by Dr. E. C. Cherry and colleagues of the Department of Electrical Engineering, Imperial College, and demonstrated how recognition of electronically 'clipped' speech is accomplished. Binaural location of sounds was also shown. The progress made in the United States in underwater recording was emphasized by a demonstration of the acoustic emission of whales by Dr. W. E. Schevill, of the Oceanographic Institution, Woods Hole, Massachusetts. The technical problems inherent in such studies were made apparent by recordings of American marine noises made by Dr. Martin Johnson, of the Scripps Institution of Oceanography, University of California; a high-level background noise interfering with recording of fish noises was eventually traced by him to its origin in large populations of 'snapping shrimps'. The single, irregular cracking noise produced by each individual shrimp drifting in the sea, when multiplied by the number of shrimps within range of the microphone, produces a frizzing background noise of high level. British interest in underwater acoustics was underlined by Mr. N. B. Marshall, of the Department of Zoology, British Museum (Natural History), who said that it was hoped that a start would soon be made on recording in the English Channel.

Bird sounds were introduced by Dr. R. G. Busnel, director of the Laboratoire de Physiologie Acoustique, France, who, in collaboration with Prof. H. Frings, of Pennsylvania State University, has recorded the songs of French and American crows to see if their sound signals were similar, or if they had evolved separate 'dialects' of their own. Dr. J. H. Elgood, Biology Department, Ibadan, Nigeria, played some recordings of the songs of Nigerian birds in the wild. Insect acoustics was represented by several workers. Dr. J. W. S. Pringle, Zoological Laboratory, Cambridge, played recordings made by him in Ceylon of the songs of several species of cicadas, and Mr. E. F. Woods, of the B.B.C., demonstrated his work on the sounds of colonies of honey bees, while developing an electronic device, the 'Apidictor', which can assist apiarists in detecting the onset of swarming in hives. Mme. G. Richard, Laboratoire de Zoologie, Rennes, demonstrated recordings of the underwater noises made by corixids, while Dr. W. Loher, Department of Zoology, Imperial College, and Dr. P. T. Haskell, Anti-Locust Research Centre, London, showed some results of their investigations on the stridulation of grasshoppers. Much of the discussion, both public and private, which developed out of the demonstrations was concerned with techniques and instrumentation, and it was therefore helpful that a number of firms, including Ferrograph, E.M.I. and Grundig, had lent apparatus for demonstration.

Time Rates of Wages and Hours of Labour

THE twelfth edition of "Time Rates of Wages and Hours of Labour", compiled by the Ministry of Labour and National Service (London: H.M. Stationery Office, 1958. 15*s*. net), contains the usual tables which show, for the majority of industries and occupations, the minimum or standard time-rates of wages, the dates from which these rates become operative, and the normal hours of labour. The rates of wages and hours of labour are those determined by voluntary agreements between organizations of employers and workpeople, or made by Joint Industrial Councils or other similar bodies, or by Statutory Orders under the Wages Councils Acts, the Agricultural Wages Acts and the Catering Wages Act. Particulars are also given, where available, of the basic rates for pieceworkers, the additional rates payable to shift and night workers, and, where they are known to exist, of the arrangements for a guaranteed weekly wage or period of employment. Three appendixes give details of rates of wages for young workers in a selection of industries, and of overtime rates of pay, and arrangements for paid holidays in the industries included in the main part of the volume.

Scientific Film Association

THE sixth annual report of the Council of the Scientific Film Association, for the year ended March 31, 1958 (pp. 12. London: Scientific Film Association, 1958), records an increase in membership from 324 to 404 during the year, and the six issues of the *Scientific Film Review* provided technical and distribution details on 335 films; similar information and a synopsis of content for a further 324 films; and full reviews or appraisals of another 451 films. Three catalogues were published during the year with detailed reviews and appraisals of 44 films on cerebral palsy, 100 films on education and 131 films on psychology and psychiatry. The film appraisal work is under continual development and a report on "The Evaluation of Scientific, Industrial and Medical Films" previously published in the *Scientific Film Review* will shortly be re-issued as a pamphlet. The Association has dealt with a wide range of inquiries about films and film making, and besides arranging a varied programme of meetings, held a residential course at Kingsgate College in March on the use of films in supervisory training. As the national representative, it plays an active part in the work of the International Scientific Film Association.

Semi-conductors

A VALUABLE guide to the use of semi-conductor devices, compiled by a committee consisting of representatives of fifteen manufacturers of semi-conductor devices in the United Kingdom, has recently been published on behalf of the manufacturers by the British Radio Valve Manufacturers' Association (The Use of Semi-conductor Devices. Pp. iv+36. London: British Radio Valve Manufacturers' Association, 1958). It is intended to assist equipment designers to secure optimum performance and life from the devices, which consist basically of monocrystalline material. In the case of diodes and transistors the substances are either germanium or silicon, and in the case of photosensitive devices they include also compound semi-conductors such as lead selenide or indium antimonide. The booklet is divided into four sections dealing with, respectively, general considerations, for example, frequency limitations, ratings, temperature and high-energy effects, of semi-conductor devices; semi-conductor diodes; junction transistors; and photo-sensitive devices. The information given is very carefully and clearly set out. A detailed index allows easy and quick reference to any particular item discussed in the guide.

Low-Temperature Thermometer

EMPHASIS on low-temperature research, particularly low-temperature calorimetry, has highlighted the need for a thermometer which indicates low temperatures accurately and reliably and does not need continual calibration. Germanium can be doped with arsenic to produce a high and fairly constant temperature coefficient at temperatures near to the boiling point of helium, and a germanium resistance thermometer of high sensitivity and exceptional stability in the temperature range near to the absolute zero has been developed by J. E. Kunzler, T. H. Geballe and G. W. Hull of Bell Telephone Laboratories Ltd. The thermometer consists of a single crystal of arsenic-doped germanium, $0\cdot025 \times 0\cdot020 \times 0\cdot210$ inches, with attached current and potential leads and supported in a strain-free manner in a platinum-glass enclosure filled with a small amount of helium. Temperature is determined by measuring the potential drop due to resistance when a current of approximately 10^{-7} amp. is passed through the germanium crystal. A typical thermometer had a resistance of one ohm at room temperature, 14 ohms at 10° K. and 216 ohms at 2° K., but both the temperature coefficient and the actual resistance vary widely with minute changes in the amount of doping, so that thermometers of differing characteristics can be made. Once calibrated the thermometer is reproducible to better than a few ten-thousandths of a degree at the boiling point of helium (4·2° K.) even after repeated cycling from room temperature to 1° K.

Megaspore Tetrads in a Coenopterid Fern

W. G. Chaloner has observed and described a new type of fossil spore tetrad, *Didymosporites scotti gen. et spec. nov.*, from Carboniferous strata in Ireland, Scotland and England, which may be the megaspores of the cenopterid fern *Stauropteris burntislandica* (*Annals of Botany*, N.S., 22, 197; 1958). The spores always occur as tetrads consisting of two large and two minute spores with cutinized walls, the former presumably fertile, the latter abortive. The evidence from studies of the distribution of these spores indicates that this species was much more widely distributed in time and space than has been previously known. The conformation of the coherent tetrads raises the question as to whether they were 'shed' while still within the megasporangium, as in *Lepidocarpon* and pteridosperm seeds.

Combustion Institute Awards

Dr. Bernard Lewis, president of the Combustion Institute, Pittsburgh, Pennsylvania, is the first recipient of the Institute's Bernard Lewis Medal awarded "for brilliant research in the field of combustion, particularly on minimum ignition energy". The Alfred C. Egerton Medal of the Institute was awarded to Sir Alfred Egerton, professor emeritus of the Imperial College of Science and Technology, London, and chairman of the British Section of the Combustion Institute, "for his distinguished, continuing, and encouraging contributions to the field of combustion". The Combustion Institute Silver Medal was awarded to Prof. Seiichiro Kumagai and Hiroshi Isoda, of the University of Tokyo, in recognition of "an outstanding paper presented at the Sixth Symposium on Combustion" at Yale University in 1956. Similar awards will be made at each biennial symposium. The Eighth International Symposium on Combustion will be held in 1960 at California Institute of Technology, Pasadena.

X-Ray Analysis and Electron Microscopy of Metals

The X-ray Analysis and Electron Microscopy Groups of the Institute of Physics will hold a joint conference on "Precipitation in Alloys" on Friday, November 28, at the Institution of Civil Engineers, Great George Street, London, S.W.1. On the previous day the Electron Microscopy Group will hold a symposium on "Electron Staining" at the Royal Society of Arts, 6–8 John Adam Street, W.C.2, while on the day following the joint conference, the X-ray Analysis Group will discuss the examination of metals by X-ray diffraction at a meeting at the Institution of Civil Engineers. An exhibition of apparatus, etc., is being arranged at the Institution of Civil Engineers. Non-members of the Institute of Physics may attend these meetings; they should complete an application form to be obtained from the Honorary Secretary of the X-ray Analysis Group, Dr. R. L. Gordon, Safety in Mines Research Establishment, Portobello Street, Sheffield 1, from whom further information may be obtained.

Announcements

Mr. E. Lord of the British Cotton Industry Research Association has been awarded the Warner Medal of the Textile Institute.

Dr. Roger Revelle, director of the Scripps Institution of Oceanography, University of California, has now been appointed to the additional post of director of the University's new Institute of Technology and Engineering at La Jolla.

Prof. R. H. S. Thompson, professor of chemical pathology in the University of London at Guy's Hospital Medical School, Prof. E. J. Wayne, regius professor of the practice of medicine in the University of Glasgow, and Prof. B. W. Windeyer, professor of radiology in the University of London and director of the Meyerstein Institute of Radiotherapy at the Middlesex Hospital, have been appointed members of the Medical Research Council.

The following research studentships for postgraduate training in ecology, tenable for periods up to three years at the universities shown, have been awarded by the Nature Conservancy: *Botany:* J. M. Bradbeer (Southampton), D. Briggs (Durham), T. T. Elkington (Durham), P. J. Myerscough (Oxford), J. G. B. Newbould (Oxford), B. M. Stephens (University College of North Wales, Bangor); *Zoology:* N. G. B. Jones (Oxford), P. O'Donald (Cambridge), Miss R. M. Oldroyd (London), Miss E. A. Steel (Reading); *Geography:* J. C. Rodda (University College of Wales, Aberystwyth).

Awards for study in statistics by persons whose primary field is not statistics but one of the physical, biological or social sciences to which statistics can be applied are offered by the Department of Statistics of the University of Chicago. The awards range from 3,600 to 5,000 dollars on the basis of an eleven-month residence. The closing date for application for the academic year 1959–60 is February 16, 1959. Further information can be obtained from the Department of Statistics, Eckhart Hall, University of Chicago, Chicago 37, Illinois.

The twenty-fifth Annual Conference of the National Society for Clean Air will be held in Llandudno during October 1–3. Further information can be obtained from the Society at Palace Chambers, Bridge Street, London, S.W.1.

A meeting of the North of England Section of the Society for Analytical Chemistry will be held on October 4 at the City Laboratories, Mount Pleasant, Liverpool, 3, to discuss "Laboratory Balances".

The Antiquarian Horological Society is holding a meeting in Birmingham on October 4. Further information can be obtained from Mr. A. K. Soper, 29 Furham Field, Hatch End, Middlesex.

The eleventh Annual Conference on "Electrical Techniques in Medicine and Biology" will be held in Minneapolis, Minnesota, during November 19–21. It is sponsored by the Institute of Radio Engineers, the American Institute of Electrical Engineers, and the Instrument Society of America through their Joint Executive Committee on Medicine and Biology. Abstracts of two hundred and fifty words for short contributed papers offered for inclusion in the programme may be sent by October 1 to Mr. Robert Erskine, Minneapolis-Honeywell, 2753 Fourth Avenue South, Minneapolis, Minnesota, from whom further information can be obtained.

Erratum: In the communication entitled "Hæmoglobin *P* (the 'Galveston' Type)" by Dr. Rose G. Schneider and Dr. Mary Ellen Haggard, published in *Nature* of August 2, p. 322, the symbol μ (ionic strength) should be substituted for the symbol M (molar) throughout the text and in the legends of Figs. 1 and 2.

HIGH POLYMERS

AN International Conference on High Polymers was held at the University of Nottingham during July 21–24. This Conference, which was organized by a British committee under the chairmanship of Sir Harry Melville, was attended by nearly six hundred scientists, including an official delegation of twelve Russians and altogether 150 foreign specialists—from twelve nations—in the physics and chemistry of high polymers.

The Conference provided a timely opportunity for a full exchange of views between those working in the high-polymer field at universities and in industrial and government research laboratories. The main themes selected for discussion were : (*a*) reaction mechanisms and kinetics with special reference to heterogeneous polymerization, including trapped radicals. Production of graft and block co-polymers; (*b*) physical, thermodynamic and mechanical properties of high polymers. The papers, which were preprinted and circulated before the meeting, were limited to forty-four.

It is now becoming accepted practice at international polymer meetings for Prof. H. Mark of the Polytechnic Institute of Brooklyn, New York, to deliver the opening address, and on this occasion he summarized in a masterly manner recent developments in the preparation and synthesis of stereospecific polymers, and the structural importance of helical configurations in understanding the properties of these polymers.

The discovery in 1953 by Karl Ziegler that catalysts formed by interaction of a metal alkyl of groups I, II and III elements with certain transition metal compounds polymerize ethylene rapidly to a high molecular weight polyethylene at room temperature and atmospheric pressure opened up a wide and important field of the study of heterogeneous polymerization, and several papers were devoted to a study of the mechanism of the action of Ziegler catalysts. Many catalytic systems have been found to be equally effective in polymerizing ethylene and other olefins at low pressures, and one of the Russian papers dealt with the use of chromium and molybdenum oxides for this purpose. Catalysts of this type are used commercially in the United States for the synthesis of polyethylene of high molecular weight. There is much evidence that soluble complexes formed by interaction of certain titanium compounds and metal alkyls polymerize ethylene in solution at normal temperatures and pressure homogeneously, although at a rate much lower than that of typical heterogeneous catalysts. Catalysts of this kind are probably more amenable to mechanistic study,, and detailed experimental kinetic results were presented on the polymerization of ethylene by homogeneous catalysts made from the interaction of aluminium triethyl and *sec*-butyl titanate, and zinc di-*n*-butyl and titanium tetrachloride in hydrocarbon solvents. Kargin and his colleagues (Moscow) reported that the mechanical properties of ethylene polymers made from catalysts formed by the interaction of organo-lithium compounds with titanium tetrachloride showed marked differences depending on the structure of the organic metallic component of the catalyst.

The most important development in the study of heterogeneous polymerization of the above type was the synthesis in 1954 by Natta and his co-workers at the Milan Polytechnic of α-olefin polymers with regular, linear, head-to-tail structures and the separation of the synthetic product into isotactic and atactic polymers. The stereospecific configuration of the former was established by X-ray methods, and a study of the nature of the catalysts enables the stereospecificity of the heterogeneous catalysts to be controlled. In this way many crystalline poly-α-olefins and di-olefins of definite stereochemical structure were synthesized for the first time. In the opening paper of the general discussion, Natta described his very extensive investigations on the kinetics of α-olefin polymerization and co-polymerization of ethylene with α-olefins. The decomposition of aliphatic diazo compounds by boron trifluoride and other boron compounds has been known for a long time to yield polymethylene of high molecular weight. From a kinetic study of this reaction Bawn and Ledwith proposed a polymerization mechanism involving boron alkyl as the true catalyst. They suggest that the polymerization is analogous to Ziegler-type polymerization of α-olefins and occurs by co-ordination with the boron, and that this results in a successive series of insertions of monomeric units into a boron–alkyl bond. An interesting example of anionic polymerization was discussed by Overberger and co-workers (Brooklyn), who postulated that the initiation process of the polymerization of methacrylonitrile in liquid ammonia is a one-electron transfer from lithium to the monomer to give an anion radical.

In 1955 it was reported in the patent literature that propylene oxide could be polymerized by ferric chloride to give products of high molecular weight which were partially crystalline. C. C. Price (1956) showed that if an optically active monomer is used the activity is retained in the crystalline polymer, and the mechanism of polymerization suggested by Price is analogous to that proposed by Natta for the heterogeneous polymerization of α-olefins. In a series of papers, C. C. Price and co-workers (University of Pennsylvania) and G. Gee and collaborators extend these investigations to other olefin oxides and show that a wide variety of catalyst systems—Lewis acid metal alkoxides, mixture of alkoxides and halides or metal halides—serve for the polymerization of propylene and other olefin oxides.

Many of the kinetic features of the polymerization of vinyl monomers in conditions in which the polymer formed is precipitated may be explained in terms of occlusion of precipitated free radicals of polymer chains. Bamford, Jenkins, Symons and Townsend reported results of the concentration of trapped polyacrylonitrile radicals as determined by electron resonance spectroscopy and the variation of this concentration with experimental conditions such as degree of swelling of the polymer, rate of photo-initiation and temperature. The fraction of radicals which become trapped was shown to be about 12 per cent in the bulk polymerization of acrylonitrile. Electron spin resonance measurements were also used by Atherton, Melville and Whiffen to follow radical concentrations in the co-polymerization of methyl methacrylate and glycol dimethacrylate.

F. S. Dainton and co-workers summarized their extensive and detailed studies on the polymerization of acrylonitrile in aqueous solution when initiated by : (*a*) Fenton's reagent, and (*b*) photochemically, using various photosensitizers. By means of the rotating sector technique they have determined both k_p and k_t and also elucidated: (1) the mechanism of the termination reaction by salts of metals of variable valency; (2) the effect of coagulation on the rate of polymerization. Other interesting observations on heterophase polymerization which were reported and discussed were: (*a*) the increase in rate of the high-energy initiated polymerization of isobutene by the presence of metal oxides of high surface area; (*b*) the effect of the physical nature of the separating phase on the rate of the heterogeneous polymerization of acrylonitrile and methyl methacrylate by Palit and Guha (Calcutta); (*c*) the co-polymerization of water-soluble sodium methacrylate with methyl methacrylate maintained in a fine particle size with the aid of water-soluble colloids.

Block and Graft Co-polymers

The general methods of synthesis of graft co-polymers have been fairly well worked out during the past ten years, and the group of papers presented to the discussion largely elaborated and consolidated these procedures, particularly with reference to the utilization of ionizing radiation, interaction of functional groups of macromolecules with monomeric and polymeric substances, and the initiation of monomers by macro-radicals. Various syntheses of graft and block co-polymers have been described in which polymers containing peroxides, hydroperoxides and perester groups may be used as initiators for the second-step polymerization, and Prof. G. Smets and co-workers (Louvain) presented kinetic results obtained with polymethylacrylate co-polymers containing *tert*-butyl perester groups and styrene monomer. A new method of synthesis of block co-polymers proposed involved the synthesis of polymers containing peroxide end-groups and the metal salt catalysed decomposition of the peroxide group in a second monomer. Prof. A. Berlin (Moscow) described the synthesis of graft co-polymers of branched structure by the polymerization of a number of monomers in latexes of polyvinyl chloride and synthetic rubbers. The preparation and kinetics of formation of block co-polymers from a primary polymer with amine end-groups which may be used as a macromolecular transfer agent and also the formation of graft co-polymers using a primary polymer with terminal double bond which co-polymerizes with a second monomer were described by Bamford *et al.* Wichterle and Gregor (Prague) reported the preparation of polymers of N-methacryloyl caprolactam. Polymer amides prepared in this way were shown to catalyse the polymerization of caprolactam, and the resulting grafted co-polymers had a three-dimensional structure. Caprolactam reacts with styrene–methyl methacrylate co-polymers to form soluble graft co-polymers, the properties of which have been studied by Chapman and Valentine. The mechanism and properties of grafts formed by polymerizing vinyl acetate monomer in the presence of polyvinyl alcohol and an alkali and a water-soluble persulphate catalyst were discussed by Hartley, and those of polymethyl methacrylate graft to natural rubber by Kobryner and Banderet (Strasbourg).

The recent interest in the use of radiation to produce new polymer hybrids has spurred a great deal of research, and four papers presented on this subject dealt mainly with grafting of vinyl monomers to polyethylene film. In general, four methods were described for producing such co-polymers: (1) Simultaneous grafting—the film being irradiated while immersed in, or swollen by, monomer; (2) post-irradiation grafting—irradiation of dry film *in vacuo* or in air, followed by addition of monomer. These various aspects were described in the papers by Metz *et al.* (Brookhaven), Chapiro (Paris) and Hoffman (Paris). Dr. Chapiro also described the radiation grafting of styrene and methyl methacrylate on to chemically inert polytetrafluoroethylene. Cooper and co-workers compared the graft co-polymers from natural rubber latex and methyl methacrylate using visible, ultra-violet and γ-radiation and measured the effects of changes of monomer concentration and radiation intensity on polymerization-rates and molecular weights. The production of cross-links and of sites for grafting in solid high polymers may be achieved by hydrogen abstraction using ultra-violet light (200–300 mμ). The rate is very much increased by the use of photosensitizers, and a comparative study of this effect with various aromatic carbonyl compounds was described by Oster (Brooklyn). Another method of grafting on to solid polymer was described by Natta (Milan) for poly-α-olefins. These hydrocarbons readily peroxide on heating in air, and the surface or internal hydroperoxide groupings (depending on the nature of the polymer) readily form free radical centres by thermal decomposition.

The mastication of polymers brought into a rubbery state on admixture with monomer causes polymerization of the monomer. This reaction was shown (Watson *et al.*) to have the characteristics of that expected if initiation was brought about by mechanical rupture of the polymer into free radicals. The preparation and properties of block co-polymers of polymethyl methacrylate-polystyrene were described.

Physical, Thermodynamic and Mechanical Properties

In a theoretical paper on rubber elasticity, Flory, Hoeve and Ciferri (Mellon Institute) generalized the rubber elastic equation of state for the case where the chain displays change in internal energy with change in conformation, and investigated the relationship between the temperature coefficient of the mean square end-to-end chain distance $\overline{r_0^2}$ and the elastic equation of state of the network. Gee and co-workers, developing the thesis that the effects of dynamic properties of linear polymers are closely related to intermolecular forces and chain flexibility, reported results on the measurement of the latter properties for poly*iso*butene. A torsion pendulum for measuring the internal friction of polytetrafluoroethylene was described by McCrum (Dupont). Results over the range 4·2° K. to the crystalline melting point at 600° K. indicated that hindered rotation occurs within the crystallites at temperatures as low as 220° K.

Several papers were concerned with the relationships between properties and structure. Meyerhoff and Cantow (Mainz) discussed the molecular weights and molecular weight distribution of branched and unbranched polystyrene, and Magat *et al.* (Paris) extended the theory of the solubility of high polymers to solution of graft co-polymers. Natta discussed the dependence of the properties of α-olefin polymers on their steric composition and summarized extensive results on the physical and mechanical properties of random, stereo and other kinds of block co-polymers.

The technical processes used for the manufacture of polyethylene yield a polymer which shows chain branching, the degree of branching varying considerably with the conditions of polymerization. Methods of measurement of branching have therefore been of paramount interest in characterizing ethylene polymers, and a considerable effort has been expended on these studies. In a detailed and elegant study, Willbourne (I.C.I. Plastics) summarized the preparation of model branched polymethylenes and calibration methods which have been used for developing methods of measuring the numbers and length of branches in polythene. The effect of branching on the degree of crystallinity, crystalline melting point, density, rate of oxidation and dynamic mechanical properties were illustrated and discussed. Gubler and Kovacs (Strasbourg) presented similar physical measurements on a range of commercial polythenes and made an interesting approach to an interpretation of these properties by considering the polymer as a mixture of n-paraffins. The orientation of crystallites which occurs on stretching polyethylene and its dependence on the degree of crystallinity were discussed by R. S. Stein (Amherst), and Eppe, Fischer and Stuart (Mainz) presented results obtained by electron diffraction and electron microscopic studies on the morphological structure of polyethylene, polyamides and other polymers.

The importance of crystallization under stress in fibre-making was emphasized in a paper by Thompson (I.C.I. Fibres), who proposed a model visco-elastic theory to explain the observed results, and de Vries (Amheim) discussed an empirical relationship between draw ratio of synthetic fibres and birefringence.

During the conference a number of technical visits were arranged to commercial laboratories and works. A reception was held on the opening evening, and the conference concluded with a dinner held in the Portland Building of the University.

C. E. H. BAWN

COMPARATIVE ENDOCRINOLOGY

DURING May 25–29, nearly 150 scientists from many parts of the world met at the Cold Spring Harbor Biological Laboratories, Long Island, New York, to take part in the Columbia University Symposium on Comparative Endocrinology. The conference was organized by a committee headed by Prof. A. Gorbman, of the University of Columbia, and the choice of Cold Spring Harbor provided an ideal setting for its deliberations. The scientific programme was split up into a number of sections or main topics.

The first of these was concerned with endocrine factors in ecological adaptation. Prof. W. Hoar (British Columbia) reviewed the role of the endocrine system in permitting fish to survive and adapt themselves to seasonal changes, while his research associate, Miss B. Baggerman, gave neat and conclusive proof of the involvement of salinity preferences in the migratory behaviour of fish.

In his interesting account of mammalian adaptive mechanisms, Dr. J. J. Christian (Bethesda) reported on the relation between adrenal size and population growth in rodents. A gradual numerical increase in the population of mice in cages, without overcrowding, leads to a significant enlargement of the adrenal glands accompanied by lowered reproductive activity (for example, a reduction in litter size), and thus, by inference, to an adjustment of population size. Whether the two phenomena are causally connected is not clear, and it may be that the increased size of the adrenals serves merely as an indicator of population density.

The next session dealt with the endocrine basis of reproductive adaptations in the major groups of vertebrates. Prof. L. Gallien (Paris) described the unusual reproductive habits of *Nectophrenoides orientalis*, a viviparous African frog with a gestation period of nine months. Dr. M. R. Miller (Stanford), in the course of his review of reptilian reproduction, stressed the hazards of inferring endocrine function from morphological study alone. As an illustration he referred to the virtual absence of histologically demonstrable Leydig cells, apparently not associated with androgen deficiency, in certain types of lizard.

In a characteristic contribution, Prof. F. L. Hisaw (Harvard) developed a theory covering vertebrates in general, in which he stressed the ubiquitous, but not necessarily biologically significant, occurrence of progesterone among chordates, and the gradual and independent evolution of luteal and placental function in different mammals, culminating with the largely autonomous placenta of primates.

Both the comparative morphology and physiology of the principal endocrine organs and endocrine function in developing vertebrates received considerable attention during the conference. Prof. E. Wolff (Paris) and Profs. A. Raynaud (Institut Pasteur) and L. J. Wells (Minnesota) reviewed the results of their, by now classical, experiments on somatic or endocrine growth and sexual development in mammalian embryos deprived of either the pituitary or gonads.

In the course of a comprehensive survey, Prof. A. Gorbman (Columbia) directed attention to the vagaries of thyroxine formation in lower vertebrates. Thus, certain types of fish and salamanders form thyroxine from labelled iodine administered to them only after protracted periods (lasting more than a month), while others may not do so at all. Interestingly enough, there is at least one type of frog in which the thyroid gland is completely absent but the larvæ of which none the less undergo metamorphosis.

The inadvisability of applying the results of experiments in mammals to lower animals was also emphasized by other contributors. Prof. B. Houssay (Buenos Aires) and Dr. M. R. Miller (Stanford) reviewed the effects of ablation of both the adenohypophysis and pancreas in different groups of vertebrates, and revealed the following interesting position : while the combined operation in mammals leads to the preparation universally known as the 'Houssay dog', there are important deviations from this situation in lower vertebrates. Thus, birds do not develop hyperglycæmia following removal of the pancreas. On the other hand, in the urodele amphibians (for example, *Triturus*) studied by Dr. Miller, the islet apparatus is of the purely β-cell type and pancreatectomy leads to severe hyperglycæmia. Hypophysectomy, however, does not cause the expected alleviation of the condition until after some months when all inter-renal tissue has atrophied. By contrast, the islets of lizards are of the α-type, and removal of the pancreas induces hypoglycæmia instead of diabetes. Another point established by Dr. Miller is that lizards are highly sensitive to glucagon and insensitive to (mammalian) insulin, in this respect differing markedly from birds.

Similar species differences were also indicated by Dr. S. I. Segal (New York) in the course of a stimulating account which ranged far and wide over the comparative aspects of gonadotrophic action and gonadal function in mammals and birds.

It was no more than a logical step to proceed from this point to a consideration of biochemical variations of hormones among vertebrates, which formed the subject of the next session. Dr. I. I. Geschwind (Berkeley) gave a detailed review of variations in such protein and polypeptide hormones as oxytocin and vasopressin, or the melanophore-stimulating principle of the anterior pituitary, as well as of the methods available for their study. Investigations of this kind may be expected to provide an explanation of the fact that a given hormone preparation such as somatotrophin from one mammalian group may be ineffective in another, or why one hormone (for example, prolactin) may induce wholly different responses in different species.

Neuro-endocrine reflex and co-ordinating mechanisms were the topics of another session. Prof. G. W. Harris (London) discussed the hypothalamic control of thyroid-stimulating hormone secretion, and there were separate accounts of the hormonal requirements for ovulation in amphibia (Dr. C. Y. Chang and Prof. E. Witschi, Iowa), birds (Prof. A. V. Nalbandov, Illinois) and mammals (Dr. J. W. Everett, Duke). The last-named reported in detail on the ability of pituitary autografts to the kidney to become vascularized and resume their functional activity when transplanted near the median eminence of rats. These animals, he indicated, not only resumed œstrous cycles of roughly normal duration but also ovulated, and some, when mated with males, became pregnant. By contrast, transplantation of these grafts to the temporal lobe did not restore cycles.

In a similar context, Dr. K. G. Wingstrand (Copenhagen) referred to experiments in which the adenohypophysis of toads was grafted on the site from which the median eminence had been previously extirpated, and after some weeks resumed its function. This seemed to prove that the anterior lobe must be activated by substances originating in some hypothalamic area other than the median eminence, and that the latter is only a release organ.

Neurosecretion and its role in neuro-endocrine integration were discussed by Profs. E. and B. Scharrer (New York). In their view, many vital processes are not controlled exclusively by either nervous or hormonal mechanisms, but by both. Neither works as a closed system; the neurosecretory cells provide a hormonal link between nervous centres and endocrine glands, whereby their activities are intimately interrelated.

A novel and attractive feature of the conference was a further session devoted to vertebrate organs of an unusual nature or incompletely established endocrine status, such as the ultimobranchial body, Stannius corpuscle, etc. Dr. F. Baker (Columbia), in reviewing the renal thyroid of fishes, described a condition of hyperplasia and aberrant distribution of thyroid follicles of fish kept in water with a low-iodine content. Thyroid masses, developed as a result of such compensatory hypertrophy, may be found in such ectopic sites as the eye, heart and brain, but this can be prevented by transferring the animals to a high-iodine environment.

During the same session, Prof. E. J. W. Barrington (Nottingham) gave a most stimulating and beautifully illustrated account of his bio- and histo-chemical studies on iodine binding in the endostyle of protochordates. He not only showed convincingly that this, indeed, occurs (for example, in amphioxus and tunicates), but also pointed out some interesting theoretical implications of his findings. For example, since iodine binding in amphioxus is associated with the production of an alimentary type of mucus, elaboration of thyroglobulin (which followed phylogenetically later) may have been the outcome of cytochemical evolution, perhaps as an ecological adaptation by chordates to life in fresh water. With regard to the origin of the iodination process, it is of interest that iodine binding also occurs in the surface layer of the tunic of tunicates, possibly as a random binding to scleroprotein. Since, however, the tunic surface is being continually worn away, it is conceivable that the iodination products might, by ingestion, have become incorporated by the animals, at some stage of evolution, into their biochemical processes. This, in turn, may have established the need for a more concentrated and efficient iodination process, and thus have initiated the iodinating function of the endostyle, itself the forerunner of the vertebrate thyroid gland. Although speculative at present, these conclusions may be given a firmer basis by future research.

The increasing use now being made of electron microscopy in the investigation of ultra-structural detail was very evident during the conference. A considerable proportion of contributors had included electron microphotographs, some of the best being those of Dr. J. D. Green (Los Angeles) and Sir Francis Knowles (Marlborough College). The standard of illustrations, in general, was remarkably high. There were many admirable colour slides—few perhaps finer than those shown by Prof. Barrington and Drs. Miller and Knowles. The superb colour film of the rat's ovary during the process of ovulation prepared by Prof. R. J. Blandau (Washington) must also be mentioned in this connexion.

The official proceedings of the entire conference will be issued as a separate volume, publication of which is confidently predicted before the end of the year.

P. ECKSTEIN

GLASGOW UNIVERSITY EXPEDITION TO NORTH RONA AND SULA SGEIR

AN expedition to the remote, uninhabited Scottish islands of North Rona and Sula Sgeir (45 miles north-west of Cape Wrath) took place during June 23–July 23. Arrangements for the expedition were made largely by four members of the University of Glasgow, D. E. Baird, I. O. Macdonald, R. S. Wyburn and S. B. Donald. The other six members of the expedition were Miss Helen C. Nisbet and R. A. Gailey

(University of Glasgow); Mr. and Mrs. M. Lauder-Smith; T. B. Bagenal and H. T. Powell (Marine Station, Millport). The present account refers principally to work carried out on North Rona; one day only was spent on Sula Sgeir.

North Rona is composed of Lewisian gneiss, granulitic in texture and showing strong differentiation into acidic and basic fractions. A notable feature is the occurrence of sheet-like intrusions of quartz–felspar pegmatite with a coarse graphic structure, the outcrops of which are largely controlled by folding along W.N.W.-trending axes. Ample evidence for glaciation exists, but no indication of the direction of ice movement could be found. A thin cover of boulder clay, containing erratics of mainland rocks, exists over most of the island. Remnants of wave-cut platforms were noted, and the approximate heights of the principal morphological features were determined.

The expedition made a detailed ground survey of the remains of Saint Ronan's cell and chapel, the church enclosure, and the adjacent village which has been deserted since 1844. The cell is rectangular with sloping walls and a roof of flat slabs, and may date from the eighth century; the adjoining chapel is later in date and has been used as the village church. The original foundation was probably a hermitage. The village is situated towards the north-west corner of an infield of some 24 acres, cultivated in large lazybeds. There are three groups of ruins in the village, each consisting of a rectangular dwelling surrounded by a number of small circular or oval cells.

A survey of the terrestrial flora was carried out and a collection made of the flowering plants, bryophytes and lichens. Only 44 species of flowering plants were found on North Rona, and Sula Sgeir has only seven. Soils were examined *in situ*, and samples brought back for further study. A comprehensive collection of terrestrial invertebrates was made, and ecto- and endo-parasites were collected from some of the 140 sheep on Rona. Selected blood samples and blood-sucking insects were taken for the Ruchill Virus Research Laboratory.

A survey of the marine flora and fauna was made on both islands and, considering the isolation of the islands and the very severe exposure to swell and wave action, a surprisingly large number of algae and invertebrates was found. One of the rarest and most interesting algae present was *Fucus distichus* subsp. *edentatus*. North Rona is the largest known breeding ground of the Atlantic grey seal, and it is of interest to record that one seal calved successfully as early as July 6; the earliest calves recorded hitherto for Britain have been born in mid-August.

A census was made of the birds breeding on Rona and notes kept of the migrants passing through. Although counts of those species nesting in the sea caves were not always possible, many of the figures obtained show marked changes from the counts made before the War. Leach's petrel was of special interest, for in Britain it breeds on only very few Scottish islands, including North Rona and Sula Sgeir; its distribution and numbers on Rona were estimated, and some 500 were ringed. Of the migrants, the most spectacular was a red-headed bunting that remained on the island for a few days.

Two films and many photographs were taken of features of interest on the islands. The results of the various investigations are now being worked up and will be published elsewhere.

The expedition is grateful to the University of Glasgow, the Carnegie Trust for the Universities of Scotland, Mr. Charles Hepburn, and other individuals, institutions and firms, for financial or other practical support for the venture; to Commander R. C. Dumas and the crew of M.F.V. 289 for invaluable assistance in getting to and from North Rona; and to Dr. R. R. Morrison of Bridge-of-Weir for transporting six members of the expedition from Rona to Sula Sgeir aboard his motor-yacht *Mary Rose of Morar*.

T. B. BAGENAL
H. T. POWELL

THE INSTITUTE OF PHYSICS

THE thirty-eighth annual report of the Board of the Institute of Physics, covering the work of the Institute during 1957, was presented to the annual general meeting of the Institute on July 1. Particular attention is directed in the report to the steady growth in the membership of the Institute during the past ten years, from 3,455 in 1948 to 5,881 in 1957. The number of applications for election or transfer to the various grades of membership received during the year under review for submission to the membership and examinations committee was 795 compared with 752 in the previous year. Representatives of the committee visited nine technical colleges which had applied for recognition by the Institute. Five colleges requested the recognition of diplomas awarded on full-time or sandwich courses as satisfying the Institute's academic requirements for membership, and two diplomas, the awards of Sunderland Technical College and the Welsh College of Advanced Technology, Cardiff, were accepted. The Board accepted the recommendation of the membership and examinations committee that students following courses in recognized institutions leading to qualifications recognized by the Institute should be eligible for admission to the student grade of membership irrespective of compliance with the Institute's regulations concerning general education, but students who do not comply will still be required to do so before being eligible for the graduateship grade of membership.

In the written papers for the examination for the graduateship grade twenty-one of the sixty-eight candidates satisfied the examiners. There were 542 candidates for the Ordinary National Certificate in applied physics and 182 for the Higher Certificate, compared with 424 and 152, respectively, in 1956.

The circulation, both to members and non-members, of the Institute's two journals, the *Journal of Scientific Instruments* and the *British Journal of Applied Physics*, increased during the year. Supplement No. 6 of the *British Journal of Applied Physics*, containing a selection of the papers presented to the Institute's Non-Destructive Testing Group, including most of those read at the Group's conference held in Bristol in July 1956, was published in May. In the "Physics in Industry" series, a new volume "Pressure Measurement in Vacuum Systems", by J. H. Leck, was published during the year, together with a revised edition of Dr. J. Topping's "Errors of Observation and their Treatment" in the "Monographs for

Students" series. "A Further Handbook of Industrial Radiology" written by fifteen members of the Non-Destructive Testing Group and edited by W. J. Wiltshire, and a fourth selection of "Laboratory and Workshop Notes" reprinted from the 1953–55 *Journal of Scientific Instruments*, compiled and edited by Dr. Ruth Lang, were published by Edward Arnold (Publishers), Ltd., for the Institute.

The third convention of the Institute, held in Oxford during July 10–13, was attended by about 250 members, ladies and guests, a rather smaller attendance than expected. Lectures were delivered by Prof. N. F. Mott on dislocations and the physics of materials and by Prof. A. C. B. Lovell on recent advances in radio-astronomy. The address given by Sir Cyril Hinshelwood on July 11 in the Sheldonian Theatre on "Physics among the Sciences" was published in the September issue of the *Bulletin* (8, 300; 1957) and the lecture by Mr. Alan Bullock on July 12 on "Science and the Humanities" in the December issue (8, 380; 1957).

The Institute has nine branches in Great Britain, a Malayan branch under the chairmanship of Mr. Hon Yung Sen and an Australian branch with divisions in different states under the presidency of Dr. F. W. G. White. The New South Wales division formed a solid-state physics group, the first specialist group to be formed in the Australian branch. In addition to the branches in Great Britain, there are seven specialist subject groups—applied spectroscopy, education, electronics, electron microscopy, non-destructive testing, stress analysis and X-ray analysis—which arrange their own programmes of scientific meetings and conferences.

The Board through its permanent officers has continued to give advice in answer to individual inquiries concerning professional matters, and inquirers requesting assistance in filling vacancies for physicists were advised to advertise in the *Bulletin*, which has now become a recognized medium for this purpose. In reply to the Scientific Manpower Committee of the Government's Advisory Council on Scientific Policy the Board stated that the members of the Board were generally agreed that if the number of graduates in physics were doubled within five to ten years the demand could still exceed the supply, and that the Board was perturbed by the number of first-class physicists who were leaving the country for permanent employment overseas. The results of the fourth survey of salaries and emoluments paid to fellow, associate and graduate members of the Institute were published in the January issue of the *Bulletin* (8, 19; 1957) and reprints were widely distributed. Discussions with the Physical Society for closer collaboration between the Institute and the Society have progressed favourably, and an announcement of interest will shortly be made.

To mark the completion of twenty-five years as secretary and editor, and in recognition of his services to the Institute, a presentation was made by the Board to Dr. H. R. Lang.

At the general meeting of the Institute, the following were elected to take office on October 1: *president*, Sir George Thomson; *vice-president*, Dr. R. W. Sellars; *hon. treasurer*, Dr. J. Taylor; *hon. secretary*, Prof. F. A. Vick. Sir William Lawrence Bragg was elected to Honorary Fellowship.

S. Weintroub

COUNCIL FOR THE PRESERVATION OF RURAL ENGLAND

THE thirty-second annual report* of the Council for the Preservation of Rural England, covering the period May 1957 to April 1958, again stresses the impact which the nuclear power programme is likely to have on the appearance of the countryside. Probably less than a tenth of the population are directly concerned with the land, and it is the urban majority which dictates, in the main, the shape of future developments. The Council welcomes the formation, on Mr. Duncan Sandys's initiative, of the Civic Trust for the encouragement of good architecture and civic planning and the stimulation of interest of urban and suburban dwellers in the visual aspect of town and country and the avoidance of unsightly development. The work of the Council itself continued along the same general lines, but the volume and range of work undertaken continued to increase.

The report provides a very useful summary of the bearing on the preservation of the countryside of recent legislation, such as the Electricity Act, 1957, the Winfrith Heath Act, 1957, the Local Government Bill, the Opencast Coal Bill, the Tribunals and Inquiries Bill and the Water Bill. Considerable discussion and correspondence has taken place between the Council and the Ministry of Housing and Local Government in regard to the recommendations of the Franks report relating to inspectors' reports, and the Ministry has agreed to supply the Council or its branches with copies of such reports on request. The use of land by Service Departments continued to demand much attention, and concern is expressed at the tendency of the Electricity Authorities to adopt the line of least resistance. The protracted negotiations regarding the routing of the electricity supply to the television station on Sandale Fell (Cumberland) are described in some detail as illustrating the meticulous care taken by the Minister of Power to give effect to his undertaking to try to reconcile the claims of landscape beauty with the urgent need to provide electricity in rural areas as economically as possible.

Numerous other instances are cited in the report in which the Council has had to raise objections, and mineral undertakings and roads and footpaths have also been the source of much anxiety, particularly the use of the Kendal to Keswick road over Dunmail Raise by heavy industrial traffic. The Council urges strongly that heavy industrial traffic should be discouraged from using this road by suitable improvements to the west coast road to make this an attractive alternative, and also by developing the alternative route through the Lune valley. This matter is regarded as particularly urgent, and the problem is being thoroughly investigated by traffic experts of the Automobile Association and the Royal Automobile Club.

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* Council for the Preservation of Rural England. Thirty-second Annual Report, 1957–1958. Pp. 64+4 plates. (London: Council for the Preservation of Rural England, 1958.)

COLLECTED PAPERS OF THE ROWETT RESEARCH INSTITUTE

THE work done at a large research centre such as the Rowett Institute is necessarily published in a wide variety of journals. It is therefore very helpful when, at regular intervals, a collection of its recent publications becomes available. Volume 14 of the Rowett Institute papers has just been issued*. It contains reprints of more than 60 papers and cites another 30 by title only. Practically all the 94 publications appeared in 1956 and 1957. Several of them will be of interest mainly to the practical man since they deal with subjects of such considerable practical importance as winter grazing in north-east Scotland, methods of extending the grazing season, the rearing of calves and the management of the breeding ewe. A large proportion of the papers, however, are devoted to the valuable basic research work done by the Institute on subjects such as the biochemistry, physiology and microbiology of the rumen, water metabolism in the sheep and energy expenditure in livestock. Some of the other fundamental work described in the collected papers is concerned with the metabolism of short-chain fatty acids and with enzyme studies, particularly work on the glucuronidases.

An important feature of the volume is the fact that it contains a summary extending to 54 pages which is also issued separately from the bound volume and which can be obtained by applying to the Rowett Research Institute. This separate summary begins by giving an account of the history and aims of the Institute, and contains not only a list of all the papers that are collected together in the bound volume with their titles and references, but also a concise account of the work they describe written by the director, Dr. D. P. Cuthbertson. The summary contains also two review articles which are in fact progress reports on two sections of the Institute's work. One deals with glycosidases and their inhibition by aldonolactones and has been written by Dr. G. A. Levvy. The other is a description by Dr. J. Duckworth of the work his Department has been doing on the skeleton in lactation and growth. Both the bound volume and the separate summary can be highly recommended to all who are interested in the recent advances that are now being made, not only in many practical aspects of animal nutrition, but also in the fundamental principles on which the subject is based.

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* Rowett Research Institute. Collected Papers, Vol. 14. (94 papers.) Summary and Subject Reviews. Pp. ii+54. (Bucksburn, Aberdeenshire: Rowett Research Institute, 1958.)

RIBONUCLEOPROTEIN PARTICLES FROM *ESCHERICHIA COLI*

By DR. A. TISSIÈRES and DR. J. D. WATSON

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THE amount of ribonucleic acid in exponentially growing *Escherichia coli* cells with a generation time of about 30 min. is of the order of 25 per cent of the dry weight of the organism. This value varies inversely with the time of generation and seems directly related to the synthetic ability of the cell[1-3]. About 90 per cent of this ribonucleic acid is bound to the ribonucleoprotein particles, which thus form a major constituent of the bacterial cytoplasm. These particles were first described on electron micrographs of *E. coli* lysed by phage[4], and later it was discovered that they contain the bulk of the ribonucleic acid of the cells[5]. They have been found in extracts of all bacterial species so far examined[5,6]. They resemble closely by their size, chemical composition, and several other properties the ribonucleoprotein particles which have been studied in detail in animal and plant tissues[7-10] and in yeast[11], and which are generally believed to be the site of protein synthesis[12,13].

In some animal tissues, such as the pancreas, most of the ribonucleoprotein particles are attached to the reticulum and they can only be isolated after dissolving the membranous material with deoxycholate[8]. In other tissues, however, most of the particles appear to be free in the cytoplasm[14]. The significance of this difference is not known. In bacterial extracts the particles are free. This suggests that they are either free in the cytoplasm or else attached to a very loose structure which collapses when the cells break open.

The early experiments of Schachman, Pardee and Stanier[5] with bacterial extracts indicated the presence of two main fractions with sedimentation constants of 29*S* and 40*S*, which suggested that the bacterial particles might be smaller than those from other sources. Recently, however, several investigators (ref. 15 and personal communication from Spiegelman, S.) have observed the presence of larger particle fractions, characterized by 60*S* and 80*S* when the bacterial extract contained a high concentration of magnesium.

The experiments to be reported here confirm the stabilizing role of magnesium, and indicate that under suitable conditions four types of ribonucleoprotein particles may be observed (32*S*, 51*S*, 70*S* and 100*S*). The 70*S* particle will be shown to break down into the 32*S* and the 51*S* components. Both these smaller units can be obtained in stable conditions, and their properties, as well as those of the 70*S* and 100*S* particles, will be reported and discussed. The sedimentation constants given here were corrected to 20° C. and zero concentration. They are 10–20 per cent higher than those of other workers. This may possibly be explained by the fact that they were measured on isolated particle preparations.

Preparation of Extracts and of Ribonucleoprotein Particles

E. coli strain *B* was grown in broth, at 37° C., under forced aeration. The cells were harvested in the logarithmic phase of growth and washed twice in the refrigerated centrifuge with the buffer used to make the extract. In most cases, the cell-free extract was made by grinding the cells at 4° C. with three parts of alumina powder and extracting with three to six volumes of buffer. Deoxyribonuclease (1γ/ml.) was always added to depolymerize the highly viscous bacterial deoxyribonucleic acid. The procedure for breaking the cells was, however, not critical: extracts made by using sonic vibrations, or by lysing the protoplasts formed following the addition of penicillin to the culture medium[16], gave identical sedimentation patterns.

The crude extract, which is the supernatant after centrifugation at 6,000*g* for 15 min., contains the bulk of the ribonucleic acid of the cells, and only small amounts of it are found in the large cell debris present in the sediment and formed of pieces of cell membranes and cell walls. The supernatant, after centrifuging the crude extract at 100,000*g* for 120 min., contains some low-molecular weight ribonucleic acid in amounts of about 10–15 per cent of the total ribonucleic acid of the crude extract, whereas the major part of this substance is found in the pellet in the form of ribonucleoprotein particles. This pellet is now re-suspended in buffer, and the particles are freed of soluble proteins by successive washings in the centrifuge at 100,000*g*.

Sedimentation Diagrams

When the crude extract is made in 0·01 *M* magnesium acetate and 0·001 *M tris* (hydroxymethyl) aminomethane *p*H 7·4, and the particles from it are resuspended in 0·005 *M* magnesium and dilute *tris*, the schlieren diagram shows a major peak with a sedimentation constant of 100*S*. In addition there is a small amount of a 70*S* peak.

If the particles are resuspended in dilute *tris* containing 0·001 *M* magnesium, there is a major 70*S* peak and small amounts of 32*S*, 51*S* and 100*S* peaks. At a still lower effective magnesium concentration (this is the case with 0·001 *M* magnesium together with 0·01 *M* phosphate buffer, *p*H 7·0) the bulk of the ribonucleoprotein particles is present as 32*S* and 51*S* components. The 70*S* and the 100*S* peaks are not visible. At these magnesium concentrations the transitions are freely reversible, and they can be obtained by dialysis against lower or higher magnesium concentrations. However, at less than 10^{-4} *M* or more than 2 × 10^{2} *M* magnesium, irreversible damage occurs and the particles break down to smaller pieces.

The 32*S* and the 51*S* peaks always appear simultaneously and, as judged by the area under the schlieren curve, the mass of the 51*S* fraction is double that of the 32*S* one. This, together with the fact that the molecular weight of the 32*S* particle is probably half that of the 51*S* one (see below), would indicate that each 70*S* particle is formed of one 51*S* and one 32*S* component. The relation between 70*S* and 100*S* particles is most likely a monomer–dimer transition. Electron micrographs of 100*S* preparations show large numbers of spherical particles in groups of two, whereas 70*S* preparations reveal a majority of isolated spherical bodies (Dr. C. Hall, personal communication).

Isolation of the 51S Component

The crude extract, prepared in 0·01 *M* phosphate buffer *p*H 7·0 and 0·001 *M* magnesium, is centrifuged at 100,000*g* for 120 min. The supernatant containing the soluble proteins is poured off, and the pellet is resuspended in the same buffer. This is now centrifuged at 100,000*g* for 90 min., the supernatant is poured off, and the pellet is resuspended as above. This step is repeated twice. Finally, the preparation is brought to *p*H 5·0 by addition of 0·1 *N* acetic acid and it is centrifuged for 30 min. at 20,000*g*. The supernatant is collected and neutralized with dilute ammonia. The 51*S* preparation thus obtained is pure according to the following criteria: (1) it shows only one peak in the centrifuge; (2) it moves as a single peak in the electrophoresis apparatus between *p*H 4·7 and 7·6; (3) it shows only one kind of particle on electron micrographs (Dr. C. Hall, personal communication).

Isolation of 70S–100S Components

The crude extract was made with 0·01 *M* magnesium ion and 0·001 *M tris* buffer. Under these conditions the 32*S* and the 51*S* peaks are not visible on the sedimentation diagrams, and the 100*S* peak is higher than the 70*S*. This extract is then centrifuged at 78,000*g* for 120 min. The supernatant is poured off and the pellet, which is much larger than that obtained when the extract is made in phosphate, is resuspended in *tris* buffer and 0·005 *M* magnesium acetate. The mixture is centrifuged again at 78,000*g* for 120 min. This last step is repeated twice, and finally the pellet is resuspended in *tris* containing 0·002 *M* magnesium and centrifuged at 15,000*g* for 30 min. The 32*S* and the 51*S* peaks are not detectable in the supernatant. There is mostly a 70*S* peak with, in addition, 10–20 per cent of a 100*S* peak.

Properties of the Particles

Chemical composition. Ribonucleic acid and protein estimations were carried out on the purified preparations by the orcinol[17] and biuret[18] methods respectively, together with determinations of dry weights. Both the 51*S* and the 70*S*–100*S* particles were found to contain 60–65 per cent of ribonucleic acid and 40–35 per cent of protein. In each experiment the dry weight amounted to the sum of the weights of ribonucleic acid and protein within 1 or 2 per cent. Thus the particles are formed mostly, if not exclusively, of ribonucleic acid and protein.

The density of the 32*S* particles is the same as that of the 51*S*: both components sedimented at the same relative rate in a sucrose solution with a density of 1·25 as in 0·01 *M* phosphate. Thus it is likely that the four components are formed of ribonucleic acid and protein in the same proportion.

Are enzymes present in the particles? The results available are quite insufficient to decide this point. In bacterial preparations some respiratory enzymes have been found in the small-particle fraction rich in ribonucleic acid[19,20]. However, it has recently been reported that purified ribonucleoprotein particles are free from these enzymes[21]. We made the same observation: the reduced diphosphopyridine nucleotide oxidase activity disappears during the purification of the particles and the pure preparations are free from this enzyme system. The results show that the particles supporting the oxidizing enzymes are not homogeneous in size. This indicates that they are probably derived from a larger structure which breaks down to small pieces when the bacterium bursts open. It is likely that this structure is the cell membrane.

Stability in various conditions. The 51*S* and 70*S*–100*S* components are remarkably stable provided the required amount of magnesium is present. They are stable for more than two months in the cold in the presence of streptomycin or in the frozen state. The 51*S* preparation is stable for 24 hr. at *p*H 5·0 or 9·0, whereas the 70*S*–100*S* components break down under these conditions. If the magnesium concentration is lowered, or if ethylenediamine tetraacetate is added, the 51*S* particles initially break down into two components of 42*S* and 18*S*. The 32*S* component does not appear during this process. All four kinds of particles are affected irreversibly by salt concentration of the order of 0·1 *M*.

1–5 μgm./ml. of ribonuclease, at *p*H 7·6, had no effect on most 51*S* preparations, as judged by the appearance of the peak in the analytical centrifuge. In a few cases, however, the 51*S* peak disappeared after this treatment. This indicates that the particles can exist in somewhat different states. Generally, both the 32*S* and the 70*S*–100*S* particles were more sensitive to the action of the enzyme, but the rate at which they were affected was always considerably slower than would be the case with pure ribonucleic acid.

Sedimentation and diffusion constants. The sedimentation constants of all four components were measured both with the schlieren and the ultra-violet optics, with concentrations varying from 2 mgm./ml. down to 40 μgm./ml. In most cases, the values fell within about 2 per cent of those given above. Under these conditions the dependence on concentration was no more than 5 per cent. The salt concentration had no appreciable effect between 0·01 and 0·05 *M* phosphate and 0·001 and 0·05 *M tris* buffer.

The diffusion constant, $D_{20} \times 10^7$, of the 51*S* component was found to be 1·98. It was independent of the concentration between 0·07 and 0·20 per cent. The partial specific volume, measured with a 25-ml. pycnometer, was 0·66. Thus the molecular weight of the 51*S* particles is $1 \cdot 85 \times 10^6 \pm 10$ per cent.

The molecular weight of the 32*S* particles is about $9 \cdot 5 \times 10^5$, which is half that of the 51*S* component. This value is based on the sedimentation constant together with a rough estimation of the diffusion constant by following the spreading of the boundary during centrifugation. Thus, the molecular weight of the 70*S* component, which appears to be formed of one 32*S* and one 51*S* particle, is approximately $2 \cdot 8 \times 10^6$.

Similarity of the Bacterial, Animal and Plant Ribonucleoprotein Particles

The reversible breakdown of the 70*S* particles to the 32*S* and 51*S* components parallels the behaviour of other ribonucleoprotein particles. In both yeast[22] and pea seedlings[10], 80*S* particles break down reversibly to 60*S* and 40*S* units. It is likely that these experiments express a general phenomenon: the presence of a principal ribonucleoprotein particle of 70–80*S* and its construction from two unequal units, one twice the mass of the other.

The sedimentation constant of the 70*S* component is lower than the values given for liver (77·5*S*)[9], pea seedling (74*S*)[10], and yeast particles (80*S*)[11]. The chemical composition reported in the literature varies. For example, about 40 per cent ribonucleic acid is found in pea seedlings[10], liver[9] and yeast particles[11], whereas in the rabbit appendix they contain 65 per cent ribonucleic acid[23].

If the molecular weight of the 70*S* component is $2 \cdot 8 \times 10^6$, the ribonucleic acid content in molecular weight units is about $1 \cdot 7 \times 10^6$. This figure is very similar to that calculated for yeast and plant particles on the basis of a molecular weight of 4×10^6 and a ribonucleic acid content of 40 per cent. Thus it may be that the amount of ribonucleic acid in the particles is fairly constant, whereas the amount of protein can vary with the origin of the cells.

Summarizing, we conclude that:

(1) The ribonucleoprotein particles from *E. coli* are very similar to those of yeast, plant and animal cells. (2) For stability they need the presence of magnesium ions, and the requirement of the bacterial particles seems greater than that of particles from other sources. (3) On varying the magnesium concentration four different kinds of particles are observed with sedimentation constants of 32*S*, 51*S*, 70*S* and 100*S*. (4) The 70*S* particle is formed of one 32*S* and one 51*S* component. (5) The 100*S* particle is an aggregate of two 70*S* components. (6) The four kinds of particles appear to have the same chemical composition: they contain 60–65 per cent ribonucleic acid and 40–35 per cent protein. (7) The molecular weight of the 51*S* component is $1 \cdot 85 \times 10^6 \pm 10$ per cent; those of the 32*S* and 70*S* units are approximately $0 \cdot 95 \times 10^6$ and $2 \cdot 8 \times 10^6$ respectively. (8) The particles are relatively stable to ribonuclease.

We wish to thank Dr. J. T. Edsall for his encouragement and for the use of the analytical centrifuge, Miss B. Hollingworth for diffusion and electrophoresis measurements, and Dr. D. M. Skinner for her assistance in some of these experiments. We are also indebted to Dr. S. Spiegleman for supplying us ultracentrifuge data on his particle fractions. The work has been supported by a grant from the U.S. National Science Foundation.

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FOLLICLE ARRANGEMENT IN SKIN FROM WILD SHEEP, PRIMITIVE DOMESTIC SHEEP AND IN PARCHMENT

By Dr. M. L. RYDER

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RYDER[1] showed that in the Mouflon the secondary follicles were between the primaries instead of lying more towards one side of them, as they commonly do in many animals and in highly evolved domestic sheep. Skin has now been examined histologically from each of the main types of wild sheep, namely, Bighorn (*Ovis canadensis*), two varieties plus one unknown; Argali (*O. ammon*), three plus one unknown; Urial (*O. orientalis*), two plus two unknown; and Mouflon (*O. musimon*), three specimens.

In addition, skin has been examined from Mouflon × Soay, Soay, Shetland, a hairy West African sheep, an English and a Nigerian domestic goat, and a Barbary lamb (*Ammotragus lervia lervia*). Although much of the skin was from dried museum specimens, good preparations have been obtained, Sandison's[2] softening fluid being helpful, as it was with parchment.

All the wild sheep (Fig. 1) had secondaries between the primaries, and the primaries were in straight lines, in trios or often in groups of five. The follicles were disposed at much more acute angles than in domestic sheep, and there was an extremely large difference in diameter between the primary and secondary fibres. The primaries were coarser than the coarsest fibres of domestic sheep, while the secondaries were as fine as the finest Merino.

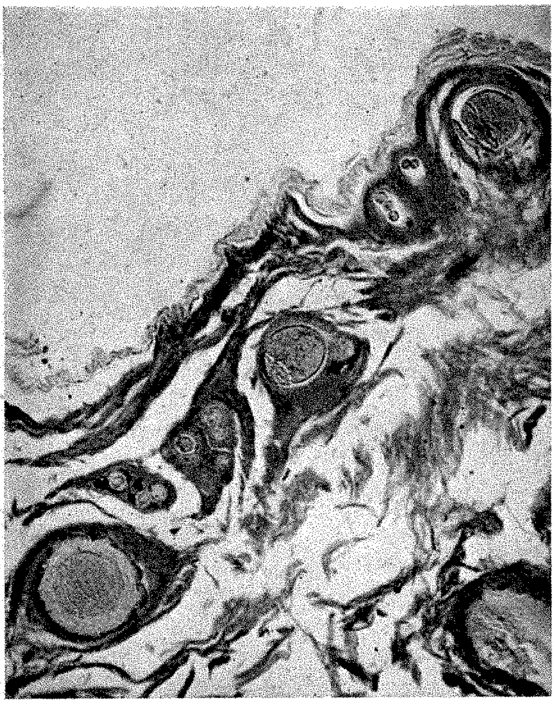

Fig. 1. Horizontal section of Urial sheep skin showing smaller secondary follicles between the primaries. (× 140)

The 'hairy primitive' domestic sheep have a large difference in diameter between the primaries and secondaries; the Black Headed Persian depicted by Duerden[3] had a strong tendency for the secondaries to lie between the primaries, and the same arrangement was found in a sheep skin from the Cameroons, believed to be from the West African Dwarf. In these, therefore, the secondaries seem to be beginning to move from between the primaries.

The Soay, a 'woolly primitive' domestic type, had clear primary trios, appreciable difference in diameter between the primaries and secondaries, and the secondaries were grouped in two wedges, only the points of which were between the primaries (Fig. 2*e*). Such an arrangement is often found in the Scots Blackface, whose latticed medullæ make it somewhat similar to the hairy group. The arrangement in the Mouflon × Soay (Fig. 2*c*) was similar to that of the wild sheep, having apparently reverted to the more primitive condition. But the primary fibres were not as coarse and did not have latticed medullæ. The Shetland had an arrangement similar to that of the Soay, but the fibres were on the whole finer, and there was less difference in diameter between the primaries and secondaries (Fig. 2*d*).

The evolutionary trend seems, therefore, to have been a movement of secondaries from between the primaries accompanied by a tendency for the primaries to move closer together and to lie on an arc. As more secondaries have developed in finer-woolled types, these have spread away from the primaries. The goat's arrangement was similar to that of the hairy domestic sheep (Fig. 2*a*) and their coats are not dissimilar. The lattices of the goat medullæ were, however, smaller and more regular than in sheep. It is interesting that the Barbary (Fig. 2*b*) was like the goat, because it suggests that the genus *Ammotragus*, considered to be intermediate between *Ovis* and *Capra*, shows, so far as follicle arrangement is concerned, greater affinity to goats than sheep.

Previous work on the ancestry of domestic sheep has neglected the skin. However, these results obtained with dried skin suggested that the examination of ancient material might provide a useful new approach. Good preparations were obtained from the skin of an ancient Egyptian mummified cat, so it would seem worth while examining any skin that is available from mummified sheep. Few follicles were found in leather, but excellent preparations were obtained from parchment. Fewer follicles were found in modern than in ancient parchment, possibly owing to the greater efficiency of the modern de-hairing process. Samples of parchment are difficult to obtain, and the only ones examined so far are: a specimen from some Aramaic documents of the fifth century B.C., which, however, are leather[4]; eighteen specimens from the Dead Sea scrolls, generally considered to be of about the time of Christ; five specimens of about A.D. 150 from the nearby

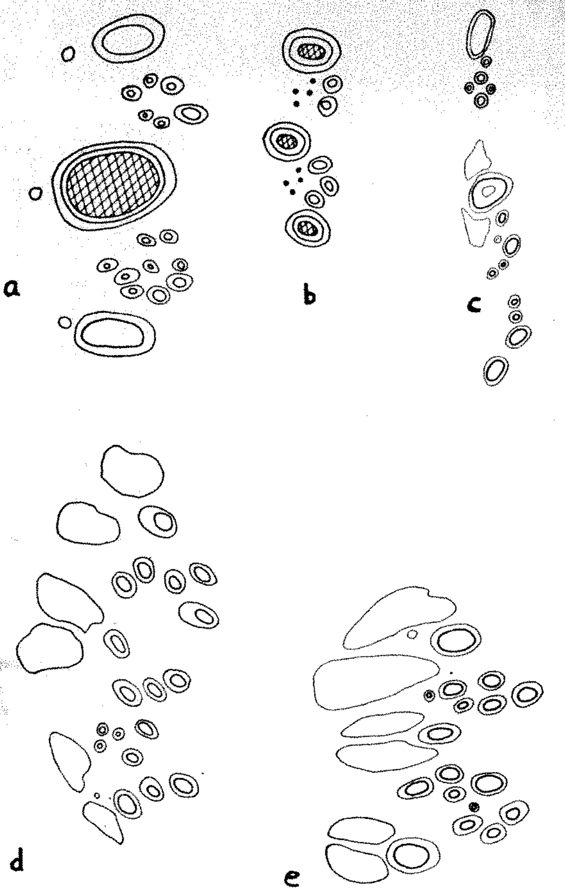

Fig. 2. Diagrams prepared from projection microscope tracings of follicle groups (ectal margin to right) from (*a*) goat; (*b*) Barbary lamb; (*c*) Mouflon × Soay; (*d*) Shetland; (*e*) Soay. Developing follicles in full black, latticed medullæ cross-hatched. Where visible, sebaceous glands have been indicated by irregular outlines and sweat glands by simple circles. Barbary lamb (× 82); others (× 41)

excavations at Murabba'at; and a sample of an English parchment dated 1692.

The histological structure of the follicles was remarkably well preserved and nuclei were often visible, although there had been some changes in staining reaction. The present description will, however, be restricted mainly to follicle grouping. This was perfect in only two Dead Sea scroll samples and two from Murabba'at, one from each of the three types of sheep found, namely, hairy, medium-woolled and fine-woolled, and a calf. All the samples showed traces of follicles, and as all but one had fibres, their type could usually be ascertained. The hairy type had large primaries with groups of small secondaries wedged between them (Fig. 3*a*). It is difficult to say whether this is from a sheep or a goat, but the secondary/primary ratio of about 4/1 suggests sheep rather than goat, which has a ratio of about 2/1. Three other samples, including one from Murabba'at, had both large and small follicles and were probably of this type.

The medium-woolled type (Fig. 4) had an arrangement similar to that of the Soay, with an appreciable difference in diameter between the primaries and secondaries, and a secondary/primary ratio of about 5/1. The fibres were non-medullated and had an irregular mosaic scale pattern, which in places approached the diagonal pattern characteristic of lustre (long-woolled) types; this is not found in the Soay. Five other scroll samples and one from Murabba'at had fibres of a similar diameter, and at least three had this diagonal scale pattern.

The fine-woolled type was most striking (Fig. 3*b*); it had large follicle groups with a secondary/primary ratio of more than 7/1. Such a high ratio and small fibre diameter are uncommon in modern British sheep, and this together with the characteristic scale pattern of fine wool suggests Merino type, which has been thought to originate in the Middle East. There were two other samples with fine fibres and the same scale pattern; a further four samples appeared to be coarser than this type, yet not as coarse as the medium type, and three samples, including one from Murabba'at, although apparently sheep, could not be classified. Two samples identified as calf, one from the scrolls and one from Murabba'at, were the only ones showing pigment.

The Aramaic documents have so far shown no clear groups; but traces of large follicles have been seen, as well as fine fibres, again suggesting a hairy type.

The English parchment of 1692 had fibres as fine as the fine type above, but the groups were smaller.

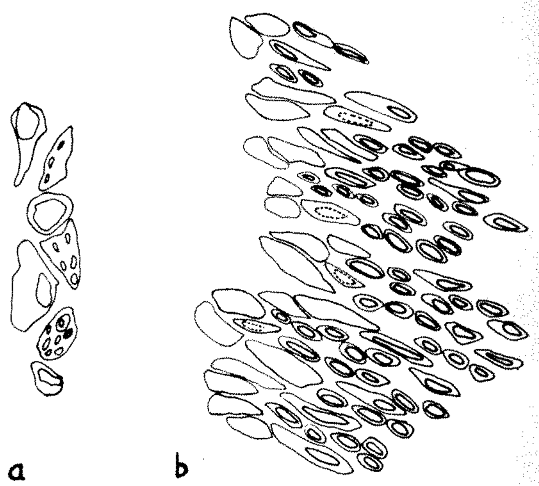

Fig. 3. Tracings of follicle groups in parchment from the Dead Sea scrolls: (*a*) hairy sheep or goat; (*b*) fine-woolled sheep (× 55)

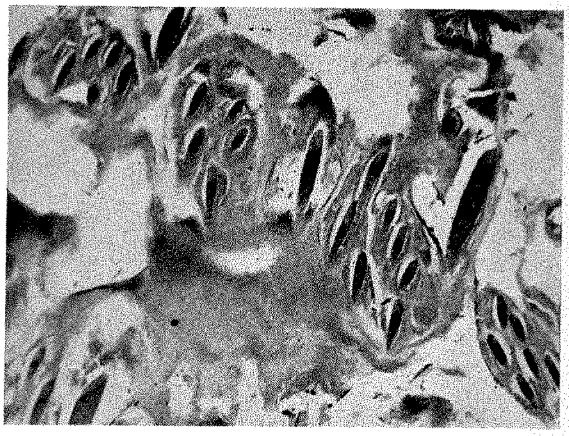

Fig. 4. Follicle group from medium-woolled sheep in parchment sample from Murabba'at (× 63)

Plug-like bodies were seen, suggesting either developing or shedding follicles; developing follicles would indicate a lamb. The fibres were finer than those of a modern day-old Romney lamb, and many of the follicles, but apparently none of the fibres, were pigmented.

It is hoped that these striking findings will stimulate the provision of material by libraries and museums, so that a more extensive study can be made, when the relation of these findings to the domestic evolution of sheep will be discussed.

I wish to thank the authorities of the British Museum (Natural History) and the Royal Scottish Museum for skin samples, Dr. A. T. Sandison for the material from a mummified cat, and Mr. W. N. Beesley for bringing a skin from the Cameroons. I am indebted to Prof. Donald Burton, Dr. R. Reed and Mr. J. B. Poole, of the Department of Leather Industries, The University, Leeds 2, for providing the material from the Dead Sea scrolls and Murabba'at and the other leather and parchment samples. My thanks are also due to Mr. G. R. Standley and Miss M. M. Vickers for technical assistance.

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SALT GLANDS IN MARINE REPTILES

By KNUT SCHMIDT-NIELSEN
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"SO they went up to the Mock Turtle, who looked at them with large eyes full of tears"[1]; " 'for I am the Crocodile,' and he wept crocodile-tears to show it was quite true"[2]. Frequent literary references to a propensity for tear production in reptiles have not sufficiently challenged scientific imagination, and an interesting chapter in the physiology of excretion has remained unnoticed.

The finding that marine birds depend on a gland in the head rather than the kidney for the excretion of salt[3] [4] suggested an investigation of their reptilian relatives, the marine turtles, crocodiles, snakes and lizards. These animals have maintained the terrestrial habit of air-breathing, and have an integument practically impermeable to salt and water. In these respects their physiology is essentially that of a terrestrial animal, but an important difference is that their food often has a high salt content, and the only drinking water available contains 3·5 per cent salt. Thus, their problems of osmo-regulation are comparable to those of marine birds.

Marine birds can tolerate the ingestion of sea water because the salt gland can excrete sodium chloride in a concentration almost twice as high as in sea water. Thus, marine birds do not suffer from the intake of sea water, in spite of the inability of their kidney to produce a urine more than about half as concentrated as sea water. The concentrating ability of the reptilian kidney is even lower, and marine reptiles could therefore be expected to have a mechanism for salt excretion similar to that in marine birds.

Marine reptiles. Reptiles with a marine habitat are found in four different orders: turtles, crocodiles, snakes and lizards.

Five species of turtles are strictly marine, going on land only to lay their eggs in the sand of tropical beaches. Their food consists of fish, some invertebrates, or seaweed. While the fish have a relatively low salt content, invertebrates as well as seaweed have the same osmotic concentration as sea water. These latter types of food, therefore, impose a heavy burden on the processes of osmo-regulation. Other turtles are found in brackish water, such as the diamond-back terrapin, *Malacolemys terrapin*. This animal is never found in truly fresh water[5].

One species of crocodile, the salt water crocodile (*Crocodylus porosus*), is estuarine in its habits, but has occasionally been found far out at sea in the Indian and Pacific Oceans. It is a carnivore, subsisting mainly on fish.

The sea-snakes, Hydrophidae, are common in the Indian Ocean. Some of the more primitive (*Laticauda*) lay their eggs on land, while the more specialized bear living young. They are all excellent swimmers and live on fish. Probably many other snakes are able to live in brackish water, an example being *Natrix sipedon compressicauda*, which is reported from brackish swamps in Florida[5].

One lizard, the Galapagos sea iguana (*Amblyrhynchus cristatus*), is well known for its appearance as well as its habits. It lives in the surf of the Galapagos Islands, where it climbs on rocks and eats seaweed exclusively[6]. A few other lizards also have been reported from a marine habitat[5].

Head glands. Several different kinds of head glands are found in the four reptilian orders mentioned. There are glands in the orbit of the eye (Harderian gland and lachrymal glands), glands opening into the nasal cavity (nasal glands), and glands opening into the mouth (salivary glands, poison glands, etc.).

In order to find whether marine reptiles are provided with salt glands we used two approaches, studies of (1) the histological structure of the head glands, and (2) the secretion obtained after a salt load, or after stimulation of the glands with the drug methacholine, a drug which stimulates glandular secretion in general.

Turtles have a large gland on each side of the head, located in the orbit of the eye. In the logger-

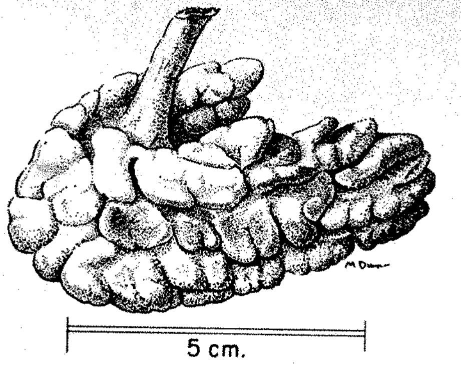

Fig. 1. Salt gland of the loggerhead turtle, *Caretta caretta*

head turtle, *Caretta caretta*, this gland (Fig. 1) is large, reddish-brown, and divided into about one hundred lobes separated by blood vessels and connective tissue. It connects to the exterior via a short, wide duct that opens in the posterior corner of the eye. The two glands weighed 60 gm. in a turtle of 130 kgm., which is 0·05 per cent of the body-weight. The relative weight of the gland was similar in the diamond-back terrapin. In the herring gull we have found the salt gland to be almost 0·1 per cent of the body-weight, and in the brown pelican 0·03 per cent.

The loggerhead gland consists of closely packed branching glandular tubules (Fig. 2) radiating from central ducts or canals in the lobes. This characteristic histological structure, which has previously been observed in the large 'lachrymal' gland of *Chelonia mydas*[7], is similar to the structure of the avian salt gland[8]. The structure of the terrapin gland is similar but less regular.

Crocodiles have well-developed nasal and Harderian glands[9,10], but the functions of these glands are not known. The nasal gland in *Crocodylus porosus* has been described as a rather large acinous gland[11].

Several sea-snakes, for example *Enhydris*, have a well-developed nasal gland[12]. It is, however, missing in one sea-snake, *Pelamis*. According to our own observations on a sea-snake (*Hydrophis ornata*) there is a gland above the eye with a histological structure resembling that of the salt gland of the terrapin. The gland consists of closely packed glandular tubules.

The marine iguana has a large nasal gland which in a specimen of 490 gm. weighed about 300 mgm. (0·06 per cent of the body-weight). Histologically the structure of this gland resembles that of the avian salt gland. The gland opens, via a short duct, into the lateral nasal cavity, which seemingly can function as a reservoir for the secretion. A ridge prevents the secretion from flowing back into the posterior part of the nasal cavity, from where it would drain into the œsophagus. On the other hand, a sudden expiration of air would force the liquid out through the nostril.

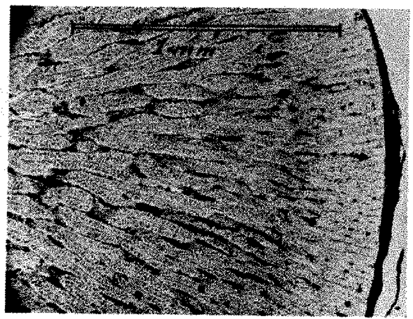

Fig. 2. Microscopic structure of salt gland of the loggerhead turtle

Secretion from salt glands. Marine turtles, when given an injection of hypertonic sodium chloride, secrete a highly concentrated salt solution from the orbital salt gland. This we could demonstrate in the diamond-back terrapin (*Malacolemys terrapin*), a brackish water turtle from Florida, which, when given 10 ml. of 10 per cent sodium chloride per kgm. body-weight, secreted a fluid which appeared as 'tears' in the eye. The sodium concentration of this fluid was 616–784 m.equiv. sodium/l. This salt concentration is well above that of sea water (about 500 m.equiv. sodium/l.).

In a large specimen of the completely marine loggerhead turtle, the duct of the salt gland was easily cannulated, and it could be established with certainty that the secretion came from this particular gland. Samples of secretion obtained after salt load and stimulation with methacholine contained 732–878 m.equiv. sodium/l., 810–992 m.equiv. chlorine/l. and 18–31 m.equiv. potassium/l. These concentrations are similar to those produced by the salt gland of marine birds.

The fact that turtles cry tears when they go on shore to lay their eggs has received much attention. The anthropomorphic interpretation that the tears are induced by the pain of egg-laying has been rejected by naturalists, who instead have speculated that they may serve to keep the eyes from drying out, or to keep the sand out. The latter obviously is not compatible with the descriptions such as that given by Carr[13]: "The curious 'crying' by nesting females (apparently a device to keep the eyes washed free of sand) has been noted in other species. The present turtle began secreting copious tears shortly after she left the water, and these continued to flow as the nest was dug. By the time she began to lay, her eyes were closed and plastered over with tear-soaked sand and the effect was doleful in the extreme".

It may instead be suggested that the turtle tears are produced in response to the osmotic load of living and feeding in the sea, and that their major role may be osmo-regulatory.

We had no opportunity to work with living specimens of the salt-water crocodile, nor with living sea-snakes. One water snake, the Mangrove water snake (*Natrix sipedon compressicauda*), which is a sub-species of the common water snake, showed no secretion from head glands when given a salt load. Stimulation with methacholine gave only slight secretion from mucous glands. We did not find any glands in the head of *N. s. compressicauda* that could be interpreted anatomically as salt glands.

The marine iguana has repeatedly been observed to blow out "a thin shower of water vapour" from the nostrils[14]. We induced secretion in two animals that had been kept in captivity for three months, by the injection of sodium chloride (10 ml. of 10 per cent solution per kgm. body-weight) and methacholine. The secreted fluid was ejected from the nostrils as fine drops.

When picking up a lizard one of us was hit in the face and eyes with a jet of droplets that had a salty taste. This rather subjective observation of a high salt content was followed by a more accurate

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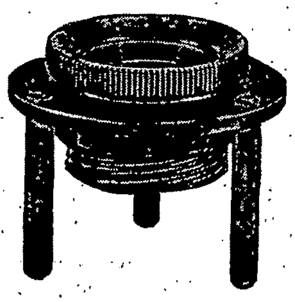

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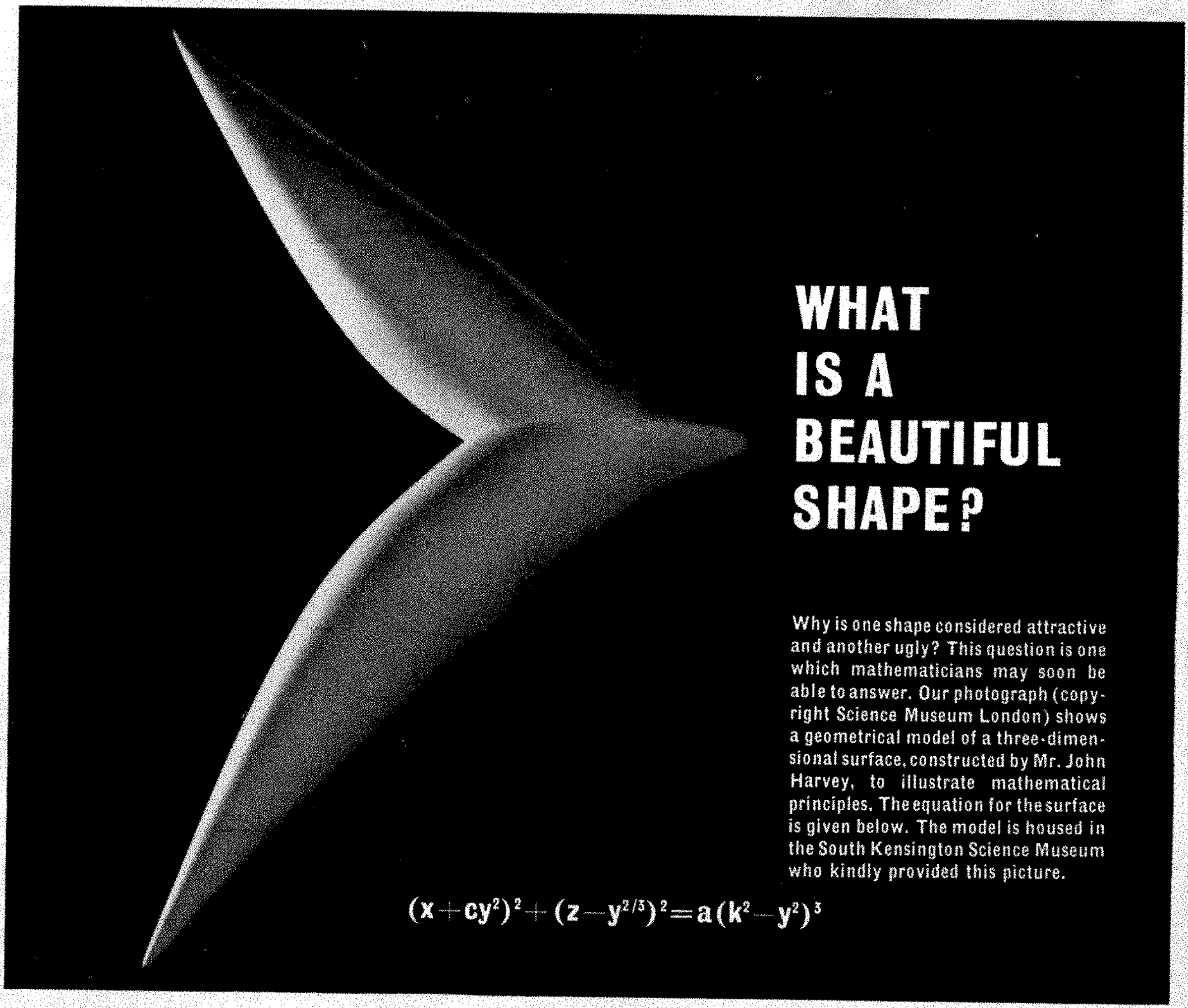

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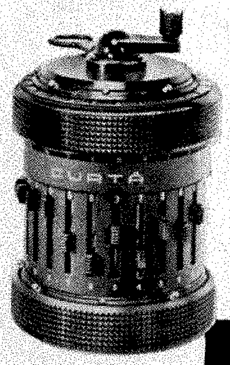

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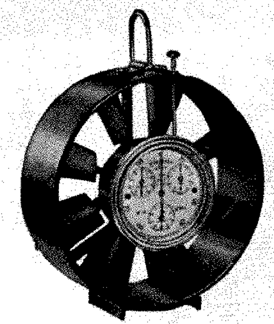

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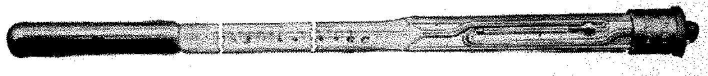

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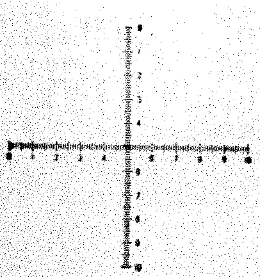

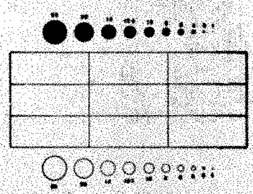

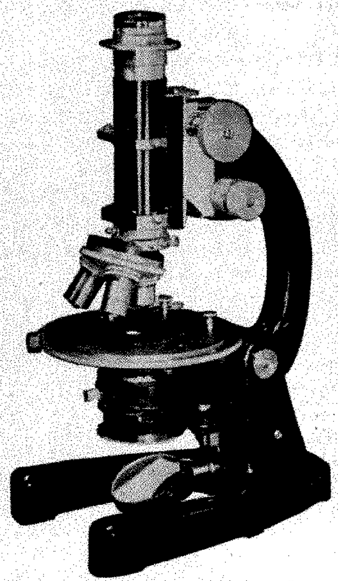

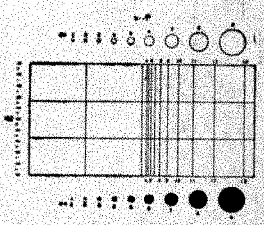

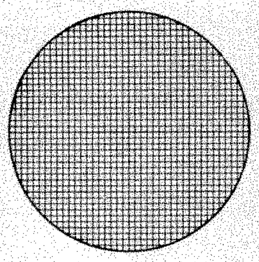

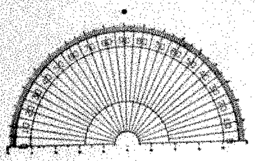

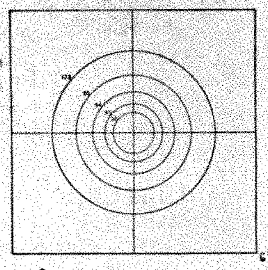

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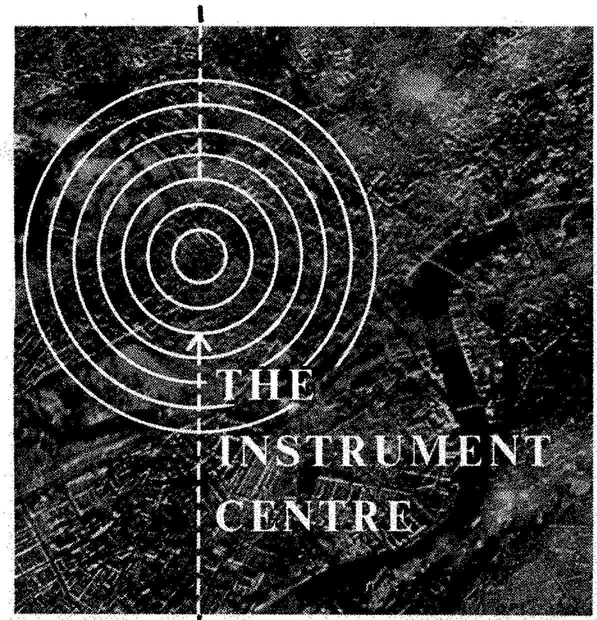

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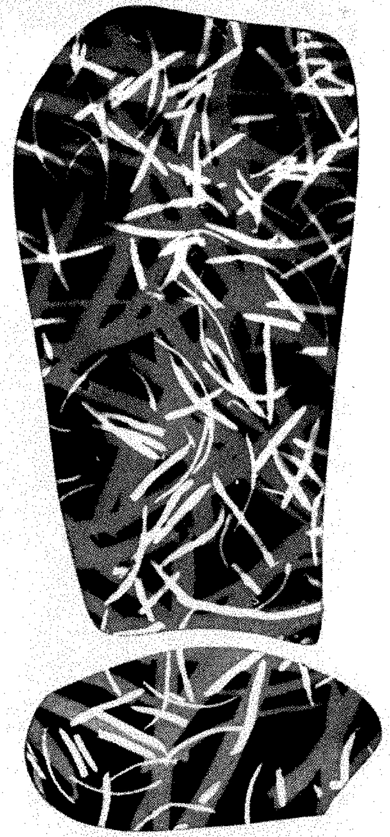

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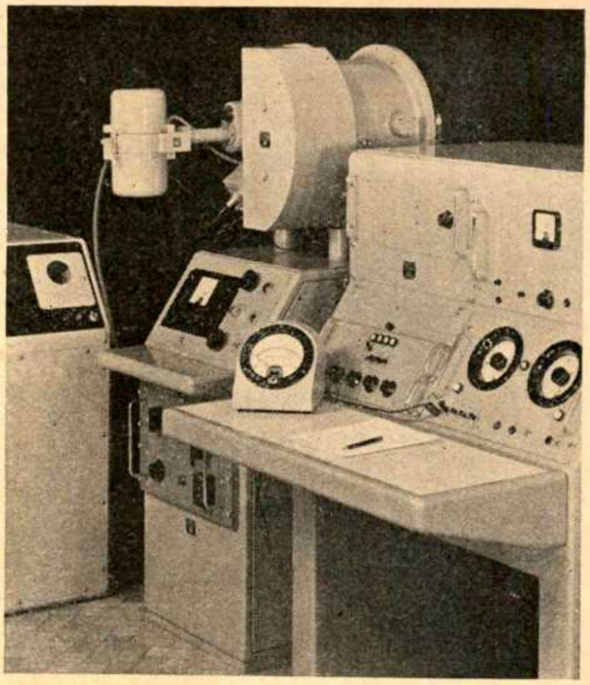

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Since the Galapagos lizard eats only seaweed which has a salt concentration similar to that of sea water, it is not only useful, but also a necessity, for it to have a mechanism for excretion of the salts in a high concentration.

In summary, we can conclude from observations described in this article that the combination of circumstantial (histological) and direct evidence (secretion of salt) indicates that an extrarenal mechanism for salt excretion is present probably in all four orders of marine reptiles, turtles, crocodiles, snakes and lizards. The secretion derives from head glands which resemble the salt glands of marine birds, both in structure and function. The kidney of birds and reptiles cannot produce a urine with high salt concentrations, and one can assume that the extrarenal mechanism for salt excretion is a necessity for successful adaptation to a marine habitat in all sauropsidians.

We wish to acknowledge the generous help and co-operation of Drs. Doris M. Cochran and H. Friedmann (Smithsonian Institution), Mr. R. Hathaway (Florida State University), Dr. R. C. Miller (California Academy of Sciences), Dr. J. A. Oliver (New York Zoological Society), and Mr. F. G. Wood (Marineland Research Laboratory, Florida). The work was supported by Grant *H*-2228 from the National Institutes of Health.

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INFRA-RED SPECTRA OF A COALIFICATION SERIES FROM CELLULOSE AND LIGNIN TO ANTHRACITE

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Department of Fuel Technology, Pennsylvania State University, University Park, Pa.

THE chemical processes involved in the transformation of the woody parts of plants into coal are not well understood. For the purpose of gaining insight into these processes, infra-red spectra of a series of coal-source materials from cellulose, lignin and wood through peat wood and a brown coal to typical bright coals of increasing rank have been compared. Significant changes in the spectra may be observed which reflect important chemical changes in the coalification series.

Characteristic spectra are reproduced in Fig. 1, and the sources of the samples are given in Table 1. The spectra were made using a 0·5 per cent concentration of finely ground sample in each case, dispersed in pressed potassium bromide plates. Consequently, the intensities of the absorptions should be only relative. Since the coals of low rank are harder to grind, the sloping background absorption in the region 2–6μ (Fig. 1) indicates that these samples were not ground finely enough to prevent some dispersion of the radiation at these wavelengths. Although this tends to decrease the relative intensity of the peaks in this region of these samples, the amount is not considered serious for making comparisons.

The strong absorption at about 8·5–10μ in the spectra of α-cellulose, holocellulose, lignin, fresh wood and peat wood (estimated to be 20 million years old) in Fig. 1 is unquestionably due to the stretching vibrations of carbon–oxygen bonds of various oxygen-containing groups which these materials are known to possess, particularly hydroxyl and ether linkages. On passing from peat to brown coal and to coals of higher rank there is a marked decrease in this absorption. Many of the coals contain considerable amounts of siliceous mineral matter which also absorbs at 9·7μ. In the coal spectra, the decrease in absorption between 8·5 and 10μ is accompanied by a corresponding decrease in the hydroxyl absorptions at 2·9μ and aliphatic carbon–hydrogen absorptions at 3·4–3·5μ. These changes accompany the disappearance of cellulose and lignin as such on passing from wood to coal, and must be due primarily to the loss of hydroxyl groups by the elimination of water molecules.

Table 1. IDENTIFICATION OF INFRA-RED SAMPLES

Sample*	Source
Meta-anthracite	Rhode Island†
Anthracite	Pennsylvania‡
Low-volatile bit.	Pocahontas, W. Va.‡
Med.-volatile bit.	*B* Seam, Kentucky‡
High-volatile *A* bit.	Pittsburgh Seam, Pa.‡
High-volatile *B* bit.	No. 6 Seam, Illinois‡
Sub-bituminous *B*	Rosebud Co., Montana§
Lignite	Bowman Co., North Dakota§
Brown coal	Washington, D.C.‡
Peat wood	Peat Bog, Ohio‡
Fresh wood	Aspen Wood‖
Sulphite lignin	Aspen Wood‖
Holocellulose	Aspen Wood‖
α-Cellulose	Aspen Wood‖

* ASTM rank.

† Obtained from Dr. H. J. Donald, then in the Department of Fuel Technology, Pennsylvania State University.

‡ Obtained from Dr. W. Spackman, Department of Geology, Pennsylvania State University.

§ Obtained from Dr. A. Traverse, then with Bureau of Mines, Grand Forks, North Dakota.

‖ Obtained from Forest Products Laboratory, Madison, Wisconsin.

* Present address: Bell Telephone Co., Murray Hill, New Jersey.

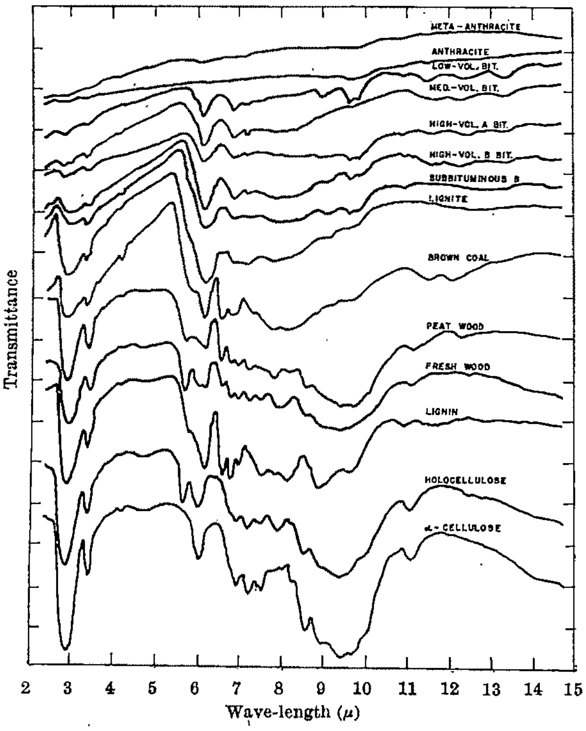

Fig. 1. Infra-red spectra of coal-forming substances and characteristic coals

Another absorption that is largely eliminated in the same early stages of coalification is the carbonyl band at 5·8μ in the spectra of holocellulose, wood and, to a lesser extent, in lignin and peat wood. In the spectra of the brown coal, this band is markedly reduced, and in the higher rank coals is practically eliminated. Adams and Pitts[1] find that bituminous coals protected from air oxidation have no band in this region. The 5·8μ band in the spectra of holocellulose and wood is believed to be due to acetyl groups which these materials contain and to the small amount of carbonyl present in the lignin structure. In peat it may be presumed that all of the acetyl groups would soon be removed by hydrolysis. This was confirmed by boiling a sample of wood with water for a number of hours and the 5·8μ absorption was reduced, similar to that in the peat spectrum. Also, the 6·0 and 7·9μ absorptions present in the fresh wood and holocellulose spectra were eliminated, with the result that the spectrum of the boiled wood was very similar to that of peat wood.

The broad absorption in the brown coal, centring at about 8μ, diminishes in lignite and coals of higher rank. This is accompanied by a corresponding loss in hydroxyl absorption at 2·9μ, and is no doubt due to the loss of phenolic hydroxyl groups as coalification progresses[2]. Since aliphatic carbon–hydrogen absorption at 3·4 to 3·5μ does not appear to decrease in intensity at the same time, it seems probable that the phenolic hydroxyl groups are not split out as water with aliphatic hydrogen atoms. Aromatic ether linkages absorb strongly at about 8μ and a part of the decrease in absorption in this region, as brown coal undergoes further coalification, may be due to the elimination of ether linkages.

The development of the strong band at 6·2μ in coal spectra (Fig. 1) is of particular interest. This is the region of double-bond stretching vibrations, particularly C=C bonds, and in coal spectra this absorption has been assigned to aromatic structures[3-5]. Other authors[6-8] have proposed that at least a part of this absorption is due to groups containing oxygen, particularly hydrogen-bonded quinones. The spectra of cellulose, holocellulose, and wood all show an absorption at 6·0μ, which may be due to hydrogen-bonded carbonyl groups, but this band disappears at the peat stage with no corresponding increase in the 6·2μ absorption. Consequently, it appears that the cellulosic constituents of wood are not the source of this absorption.

Lignin, on the other hand, has a strong 6·2μ band, which is observed in the spectra of wood, peat and the various coals to the semi-anthracite rank with but little diminution of intensity from wood to semi-anthracite. In the spectrum of lignin, the 6·2μ band is undoubtedly due to the benzene rings which this material contains. The 6·2μ band in lignin is accompanied by a second band at 6·6μ, as is frequently observed with benzene derivatives. These two bands of nearly equal intensity may be observed in the spectra of wood, peat and the brown coal, but in the lignite spectrum the absorption at 6·6μ is greatly reduced and is completely absent in the spectra of higher rank coals. This loss in absorption at 6·6μ on passing from low-rank to high-rank lignites was observed with three additional samples of the former and four of the latter, suggesting that the 6·6μ band disappears in the early stages of coalification. Brown[6] has also pointed out that the 6·6μ band is generally weak or absent in spectra of known condensed aromatic hydrocarbons containing more than three rings. This band is also absent from spectra of coal tar pitches[5], which are composed of mainly large condensed aromatic structures. Therefore, it seems probable that the cause of the disappearance of the 6·6μ band is the condensation of benzenoid derivatives characteristic of lignin into polynuclear fused-ring aromatic structures characteristic of coals[9].

The bands at 6·9 and 7·2μ in the coal spectra, together with bands at 3·4–3·5μ, have been assigned to aliphatic carbon–hydrogen groups[3,4,6]. The persistence of these bands throughout the bituminous range of coals shows that this structural element is one of the last to disappear. The absence of these bands in the spectra of anthracites may be due more to their obliteration by a general electronic type of absorption[3] rather than to a complete elimination of these structures.

A comparison of the spectra of the coalification series from cellulose and lignin to anthracite gives an insight into the chemical changes that occur during coalification. Of particular interest are the loss of oxygen and the development of aromatic absorption characteristic of condensed polynuclear aromatic structures.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Undergraduate Academic Record of Fellows of the Royal Society

At the present time the main criterion for the award of grants for postgraduate research seems to be the candidates' undergraduate academic record. As a preliminary attempt to measure the validity of this practice, we have examined the published class of degree gained by current Fellows of the Royal Society who received their first degree from Oxford or Cambridge. Our results are given in Tables 1 and 2. Oxford and Cambridge are listed separately, and in each case the results of those who graduated during the period 1920–39 are given as well as the results for the group as a whole. For the Oxford group the result given is always that gained in the Final Honours School; for the Cambridge group the results given in Table 1 are of the last Tripos taken irrespective of whether it was Part 1 or Part 2, while Table 2 gives the results of an earlier Tripos if one was taken. The figures in brackets represent the actual totals on which the percentages are based.

Table 1. Results in Final Honours School (Oxford), or Last Tripos (Cambridge)

Cambridge					Oxford				
Class	1920–1939	Per cent	1886–present	Per cent	Class	1920–1939	Per cent	1907–present	Per cent
1	(70)	76·9	(139)	78·5	1	(30)	96·8	(36)	97·3
2	(19)	20·9	(34)	19·2	2	(1)	3·2	(1)	2·7
3	(2)	2·2	(4)	2·3	3	—	—	—	—

Table 2. Cambridge Tripos Results for Part 1 and Part 2

Class		Cambridge			
Part 1	Part 2	1920–1939	Per cent	1886–present	Per cent
1	1	(50)	54·9	(95)	53·7
2 or 3	1	(8)	8·8	(14)	7·9
1	2 or 3	(10)	11·0	(20)	11·3
2 or 3	2 or 3	(7)	7·7	(9)	5·1
1		(12)	13·2	(30)	16·9
2 or 3		(4)	4·4	(9)	5·1

If we assume that Fellows of the Royal Society have demonstrated outstanding research ability and that examination standards at Oxford and Cambridge have remained relatively constant (at least during the period 1920–39), and if academic records are a good predictive criterion of research ability, we should expect to find a negligible proportion within our criterion group who gained anything other than first class degrees as undergraduates. Therefore our first finding (Table 1) that approximately 1 in 4 of the group who graduated from Cambridge during the period 1920–39 gained a second or third in their final examination, and that (Table 2) approximately 1 in 3 gained either a second or third at some time during their undergraduate careers seems surprising. Our other principal finding, namely, that the Oxford group appear to have better undergraduate records than the Cambridge group, seems open to at least two interpretations: (1) that the Oxford examination is actually a more valid index of potential research ability than is the Cambridge one; and (2) that the standards of the Oxford examinations are relatively lower than they are at Cambridge. A third possible interpretation, that the sample is inadequate to make the difference significant, is unlikely at the 0·5 per cent level of confidence using the χ^2.

Although the present data do not enable us to state the general relation between undergraduate academic achievement and research ability, we believe that considerable doubt has been cast on the use of degree class alone as a criterion for the selection of research students. In order that a more precise assessment may be made, we hope to carry out the following further investigations: (1) compare the proportion of degree classes gained by Fellows of the Royal Society with the proportion gained by the population of research students at Oxford and Cambridge during the relevant period; (2) extend the list of Fellows to include those who graduated from universities other than Oxford and Cambridge; and (3) examine other criterion groups, such, for example, as D.Sc.'s. The encouragement of Profs. F. G. Young and O. L. Zangwill throughout this inquiry is gratefully acknowledged.

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Effect of Air Drag on the Orbit of an Earth Satellite

It has been shown[1] that the first-order effect of the oblateness of the Earth can be simply incorporated in the standard analysis of the effect of air drag on a satellite orbit. However, King-Hele and Leslie[2] ignore this correction in a comparison of theory and observation on the orbit of *Sputnik* 2 (1957β) in favour of terms of higher order in the eccentricity.

There appear to be two distinct problems in the fitting of the observational data, as typified by the

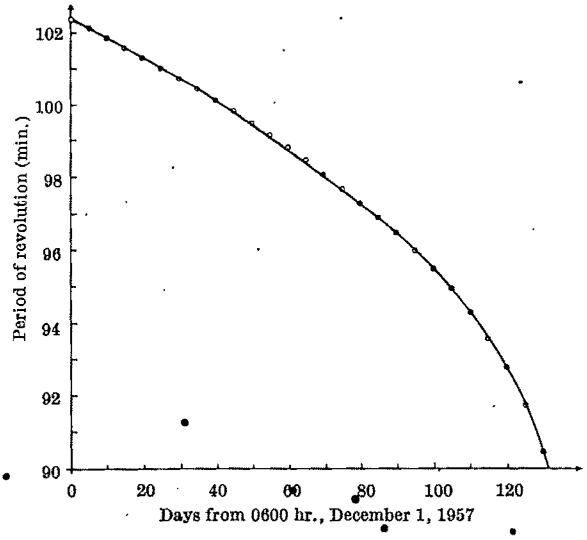

Fig. 1. Period of *Sputnik* 2 —, observed; ○, calculated

prediction of the orbital period over a range of the order of months on one hand and by the day-to-day variation in the rate of increase of the periodic time on the other. This second problem obviously requires a consideration of effects which are ignored in the customary analysis, of which the tidal influences of the Moon may well be one. However, the variations of this second type appear to be grouped about a mean behaviour consistent with the simple analysis. Thus Fig. 1 shows a comparison between the observed orbital period and that calculated on the relation given by me[1] over the period December 1–April 10. Here only first-order terms in e_0 are retained, but a correction for oblateness is included. The value of t_n was taken as 134·4 days and the scale-height was estimated at 33·5 nautical miles. The fit is decidedly better than that of King-Hele and Leslie, the only noticeable departure of the calculated values occurring in January when observations indicated a change in the effective drag cross-section. It should be noted that this agreement has not been obtained by an arbitrary assignment of parameters, since t_n is critically determined by the time of final fall and the only assignable parameter is the scale-height H. Undoubtedly the assumption of constant scale-height is violated in practice; but unless the agreement is purely fortuitous, it would appear that it varies little between 112 nautical miles and 95 nautical miles above the surface of the Earth. There is, however, some indication in the orbital data of a slight decrease in the value at lower levels.

It would seem that for prediction 'in the large' an analysis correct to the first order in e_0 but including a correction for the oblateness of the Earth is entirely adequate. This is further borne out by the fact that the failure of the asymptotic expansions of the Bessel functions at small values of the eccentricity is illusory, since the instability of the 'circular' form implies a non-zero minimum value of e. The second problem, that of accounting for the variations in the very sensitive rate of increase of periodic time, quite obviously requires considerably wider physical assumptions and is consequently beyond the scope of the present analysis.

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IN the theoretical formula for the variation of the period of revolution with time, there are three roughly equal small terms, with coefficients e^2, H/a_0 and ε (the Earth's ellipticity). Mr. Parkyn obtains a good fit by ignoring the first two of these and retaining the third. It is not altogether satisfactory, however, when two terms which should apparently be included have to be omitted. Rather it suggests that some of the assumptions in the theory need to be improved; that was why we were reluctant to assign a value of H in our article, and we should be even more reluctant to guess its variation with height.

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The Fundamental Molecular Event in Muscular Contraction

ASTBURY[1 2] suggested that the fundamental event in the contraction of muscle might involve a characteristic of the keratin–myosin–epidermin–fibrinogen group of fibrous proteins to which myosin belongs, namely, the folding or collapsing of polypeptide chains from the α-configuration into the supercontracted state. While it has been shown that isolated myosin and actomyosin supercontracts after reasonably mild chemical or physical treatment[2,3], no X-ray evidence has been forthcoming so far to show that the shrinkage of actomyosin gels after treatment with adenosine triphosphate is accompanied by a corresponding configurational change[4]. Moreover, there is the difficulty of reconciling this approach with recent concepts of a two-phase actin–myosin system shortening by close-range[5] or long-range[6] interaction of filaments coiling or sliding over one another in a regular stepwise fashion.

The demonstration by Astbury, Beighton and Weibull[7], in diffraction diagrams of bacterial flagella, of X-ray features characteristic of the supercontracted state (the 'cross-β' configuration[8]) side by side with an α-pattern having analogies with that of muscle suggests that the simplest molecular expression, of flagellar motility in any event, may be a rhythmic interchange between the α-state and a shorter supercontracted form. Recently, the discovery by Rudall[9] of a transversely folded protein in the egg-stalk of the lace-wing fly *Chrysopa* has much emphasized the possibility that there may commonly exist in Nature (as opposed to mechanical or chemical artefacts) a well-defined protein state in which the polypeptide chains lie in long regular folds[10].

We now report that the synæresis of actomyosin on addition of adenosine triphosphate is accompanied by X-ray indications of a transformation of a proportion of the protein into the supercontracted state.

The actomyosin used was extracted from the finely crushed dorsal muscle of fish by buffered alkaline potassium chloride and precipitated by lowering the ionic strength. After washing three times, with interspersed centrifugation, the actomyosin formed transparent thixotropic gels, still intensely reactive to adenosine triphosphate solutions[11] and capable of being dried on water-repellent glass blocks to form thin transparent films. The unsynæresed films could easily be stretched in moist air to give well-oriented α-diagrams characterized by the familiar meridional reflexion at about 5·1 A. After synæresis with adenosine triphosphate, the resultant opaque brittle films were difficult to handle, and the diffraction patterns of such unpromising material appeared to show only a vague sharpening on the meridian. By washing out the reactants immediately after addition of adenosine triphosphate, however, the partly contracted gels retained a certain capacity to stretch after drying, and such specimens could be sufficiently oriented to illustrate changes in the diffraction pattern.

Fig. 1 shows the diffraction pattern of a film prepared as just described of actomyosin from the dorsal muscle of the ruffe, *Acerina vulgaris*. The 'cross-β' configuration shows up as a faint preferred orientation at 4·65 A. on the meridian. The conditions for the appearance of an X-ray pattern indicating supercontraction in actomyosin appear to be very critical;

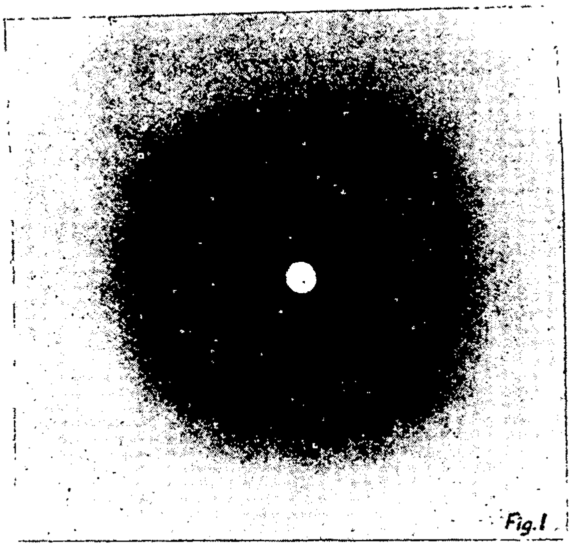

Fig. 1. Actomyosin from *Acerina vulgaris* partly contracted with adenosine triphosphate. Thin films stretched about 50 per cent in moist air and photographed with the X-ray beam parallel to the film

this is understandable if the circumstances of protein chain-folding are such as to obstruct orientation by stretching.

A detailed account of this work will appear in due course. I am indebted to Prof. W. T. Astbury for his encouragement, to Dr. K. M. Rudall for advice, and to Mr. A. Millard for reproducing the X-ray diffraction photograph shown in Fig. 1.

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Calibration of a Calorimeter: a Minor Peaceful Use for Plutonium

CALORIMETERS are often calibrated by generating a known electric current within them and observing the deflexion of the measuring instrument when the system is in a steady state. This method may suffer from the disadvantage that heat is lost along the leads through which the calibrating current is introduced. The loss of heat can be reduced by passing the leads through a block of metal maintained at the experimental temperature, though the design of the calorimeter and its water-bath may make this procedure difficult. One can also calculate the loss of heat along the heater leads, but it is not desirable to rely exclusively on estimates that cannot be verified by experiments. One alternative is to calibrate the heater against some thermochemically convenient reaction, for example, the latent heat of vaporization of a liquid[1], or the neutralization of a strong acid by a strong base[2]. These methods have their own disadvantages, and it was therefore decided to use a different method of calibration, either of the calorimeter itself or of the heater used to calibrate it.

This method, which involves putting into the calorimeter a radioactive substance in equilibrium with its disintegration products, in a radiation-absorbing container, was first used by Boivinet and Calvet in 1954[3]. They inserted into their calorimeter a platinum and gold needle containing 10 mgm. radium in equilibrium with its disintegration products, which produced about 95 mcal./hr. The radium needle was electrically calibrated in an adiabatic calorimeter in which the heat conduction along the heater leads was said to be negligible[4].

Radium has certain disadvantages for this purpose: first, radium-226 and its decay products are strong γ-emitters, which is not conducive to ease of handling in a very small calorimeter. Secondly, unless the percentage of radium-228 in the sample of radium-226 is known, theoretical estimates of the energy output of the sample cannot be precise. Plutonium-239 does not suffer from these drawbacks and has the additional advantage that its only decay product, uranium-235, is very stable, having a half-life of 7·07 × 10^8 years. Plutonium-239 was obtained by irradiating uranium-238 with slow neutrons in BEPO at the Atomic Energy Research Establishment, Harwell. The following reactions occur:

$$\begin{tikzcd}[column sep=small] {}^{238}\mathrm{U}(n,\gamma){}^{239}\mathrm{U} \arrow[r, "\beta"] & {}^{239}\mathrm{Np} \arrow[r, "\beta"] & {}^{239}\mathrm{Pu} \arrow[d, "{(n,\, 2n)}"] & (n,\gamma){}^{240}\mathrm{Pu}(n,\gamma){}^{241}\mathrm{Pu} \\ & & {}^{238}\mathrm{Pu} & \end{tikzcd}$$

The amounts of plutonium-238 and americium-241, plutonium-240 and plutonium-241 were, respectively, 0·3 per cent (by activity), 0·977 per cent and about 0·016 per cent. According to Asaro and Perlman[5], the total disintegration energy of plutonium-239 is 5·235 MeV./nucleus and the same value can be deduced from the earlier data of Gol'din, Tret'yakov and Novikova[6]. 99·6 per cent of the γ-rays emitted by plutonium-239 can be shown to be absorbed by the platinum/iridium needles in which the plutonium (as PuO_2) is contained. As 1 MeV. = 3·829 × 10^{-11} mcal. and the half-lives of plutonium-239, -240 and -238 are 24,360, 6,580 and 89·6 years[5], the heat output of the plutonium oxide can be shown to be 1·4891 mcal./mgm./hr.

The two needles containing the plutonium oxide were standard radium needles, external length 30 mm., external diameter 1·65 mm. and wall thickness 0·5 mm. They were believed to contain 41·58 and 49·66 mgm. PuO_2, though some of this may have been lost during sealing the needles. Using the value 1·4891 mcal./mgm./hr., a theoretical estimate of the heat production of the needles can be made (Table 1). The actual energy output of the needles (Table 1) was measured by Dr. W. B. Mann, of the National Bureau of Standards, Washington, D.C., using a Callendar radiation balance[7]. The radiation balance is, in fact, the microcalorimeter in which the quantity of heat to be measured is balanced against the cooling from Peltier couples, in such a way that no corrections are needed for the Joule heating in the Peltier couples

Table 1. Energy Output of PuO_2 in mcal./hr.

Needle	Calculated	Measured (Mann)
1 2	61·92 73·95	62·26 ± 0·35 74·48 ± 0·35
1 ÷ 2 (measured)	0·8326 ± 0·0043 (Mann)	0·8292 ± 0·0089 (Rothschild)

and leads. This method of measuring heat production does not have the disadvantages mentioned earlier.

Using a modified Clarke–Rothschild calorimeter[2], volume 2·4 ml., for which the plutonium oxide needles were made, I obtained a value for the ratio needle 1/needle 2 of 0·829, as compared with Dr. Mann's value of 0·833. The difference, of about 0·6 per cent, between the calculated and observed energy outputs may be due to an error in the value taken for the half-life of plutonium-239, or to the sample not being pure PuO_2, or to the amount of americium-241 present.

I am greatly indebted to the U.S. National Bureau of Standards and, in particular, to Dr. W. B. Mann, for measuring the heat output of the plutonium needles; and to Dr. G. B. Cook, of the Isotope Division, Atomic Energy Research Establishment, Harwell, for much assistance and advice. This work is supported by the Medical Research Council.

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Visualization of Mode Conversion of an Ultrasonic Beam in Fused Quartz

In investigating methods of bonding transducers to fused quartz for use in delay lines, it is very useful to be able to see how the ultrasonic beam travels through the quartz.

To visualize the paths of such beams, we have employed the optical system described by Sven Johnson[1], which makes use of the following two principles: (1) a diffraction grating is produced in the quartz by the periodic variations of density in the path of the ultrasonic beam[2]; if the quartz be viewed in a schlieren system, only the vibrating portions of the quartz should be visible; (2) in the regions of high ultrasonic strain the quartz becomes birefringent; thus, placing the quartz between crossed 'Polaroids' will cut out the effect of scattered light without blocking the ultrasonic field from view.

Fig. 1 is a photograph, taken by this method, which gives a vivid illustration of the phenomenon of mode conversion on reflexion.

On reflexion of a compressional wave at a plane interface between a solid and air, both compressional and shear waves will be reflected. Arenberg[3] has calculated that, in fused quartz at an angle of incidence of 44·8°, there will be complete mode conversion from a compressional wave to a shear wave reflected at an angle of 27·2°:

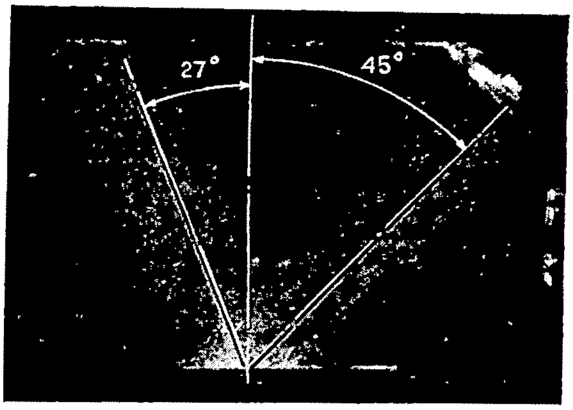

Fig. 1

$$\left(\frac{\text{sine angle incidence}}{\text{sine angle reflexion}} = \text{ratio of velocities}\right)$$

An X-cut quartz crystal, affixed to the Heraeus quartz blank by an indium bond, is excited at its resonant frequency of 8·5 Mc./s., thus injecting the compressional wave into the quartz (which has been machined to give the required angle of incidence). Fig. 1 shows the beam reflected at an angle of 27° and no sign of any reflexion at 44·8°. Some standing waves in the ultrasonic field are visible. Multiple reflexions have been reduced by absorbing material on the faces of the blank.

Acknowledgments are made to Mr. K. P. Osmond for the preparation of the bond and to Mr. A. Allen, chief development engineer of Cossor Radar and Electronics, Ltd., for permission to publish this communication.

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July 18.

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Scattering of Microwave Radiation by a Plasma Column

The purpose of this communication is to describe experiments performed to determine the angular distribution of the electromagnetic radiation scattered by the positive column of a mercury discharge under the resonant conditions which have been previously investigated[1,2]. The experiments reported here prove the multiple order of the three largest resonances shown in Fig. 1 to be dipole.

The conditions for production of the series of resonances in the scattered radiation are that (1) the E vector of the incident radiation be perpendicular to the axis of the plasma column, (2) the diameter of the column be small compared to the wave-length of the radiation, and (3) the frequency of the radiation be in the vicinity of the so-called plasma frequency.

The following experimental arrangements were made in order to satisfy the foregoing conditions.

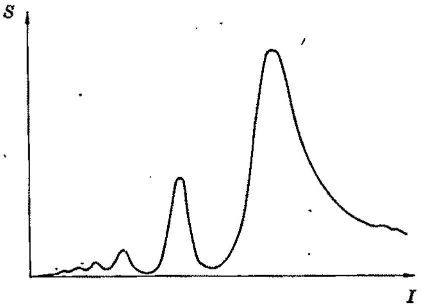

Fig. 1. Intensity of scattered radiation (S) as a function of positive column current (I). (Adapted from A. Dattner, ref. 2)

Microwave radiation of 10-cm. wave-length was coupled to a guide which was terminated by a tapered horn. The horn was arranged so that the E vector of the emergent radiation would be perpendicular to the axis of the plasma column. The plasma was contained in a glass tube of 8 mm. inside diameter and 47 cm. length. The glass tube was located directly in front of the horn at a distance of 30 cm. The discharge 'bulb', which was immersed in an oil bath, contained a mercury pool cathode and a hold anode. The bulb was connected to the lower end of the glass tube.

In order to reduce the amount of radiation scattered by the room walls and other objects, the area around the horn and scattering column was enclosed on the sides by panels of microwave absorbing material. The H component of the field of the scattered radiation was measured as a function of scattering angle using a 7-mm. diameter circular loop placed perpendicular to and 65 cm. distant from the axis of the plasma column. To minimize the amount of direct radiation from the horn to the pickup loop an additional absorbing panel was located between the horn and loop. The position of this panel was adjusted to produce a null output from the detection system at each loop position when the positive column was not ignited. Care was taken to ensure that adjustments of the panel did not measurably affect the intensity of the radiation incident on the column nor shield the loop from the column.

The positive column current was modulated by use of a 50-c./s. sine wave superimposed on a direct current. The amplitudes of the direct and 50-c./s. currents were adjusted so that electron densities corresponding to the five most pronounced resonances were swept through on each cycle.

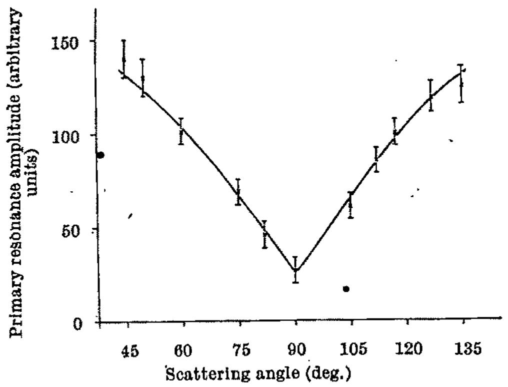

Fig. 2. Amplitude of the primary resonance as a function of the scattering angle

After amplification and detection, the loop output was displayed on the vertical axis of an oscilloscope the horizontal deflexion of which was made proportional to the positive column current. Thus the oscilloscope displayed a plot of the scattered radiation field as a function of the column current at a particular scattering angle. Using the foregoing arrangements, it was possible to determine the amplitude of the three largest resonances for scattering angles, θ, between 45° and 135° with respect to the incident direction.

Fig. 2 shows a plot of the amplitude of the largest or primary resonance as a function of scattering angle. Also shown in Fig. 2 is the curve $25 \sin \theta + 165 \cos \theta$, which is seen to provide a reasonable fit. The addition of the small $\sin \theta$ term to the anticipated $\cos \theta$ dependence of a dipole H field is due to the presence of some electrical pickup by the loop and its cable. There is no evidence of higher multipoles. Thus the primary resonance is dipole. The sizes of the plus–minus bars attached to each point were based on the accuracy with which the null adjustment of the movable absorbing panel could be made and on the noise level of the system.

Table 1. THE RATIOS OF THE SECONDARY (2) AND TERTIARY (3) TO PRIMARY (1) RESONANT AMPLITUDES AS A FUNCTION OF SCATTERING ANGLE θ

θ	(2)/(1)	(3)/(1)
45	0·27	0·12
54	0·25	0·13
60	0·23	0·10
75	0·28	0·14
82	0·24	0·09
90	0·23	0·08
97	0·27	0·07
105	0·23	0·10
112	0·27	0·15
120	0·23	0·08
127	0·29	0·12
Average ratio	0·25	0·11
RMS deviation	0·02	0·02

Table 1 gives the ratios of the secondary and tertiary resonant amplitudes to the primary resonant amplitudes as a function of scattering angle. Neither of these ratios have angle dependent trends of sufficient amplitude to indicate any difference in multipolarity among the three resonances. Thus, since the primary resonance is dipole, all three must be dipole. It is perhaps safe to suppose that the other resonances behave similarly, but the noise level of the system prohibited the accurate measurement of the higher modes.

Calculations made by Makinson and Slade[3] appear to predict multiple dipole resonances while other results[4,5] have indicated a single dipole resonance. The present experiment supports the result of Makinson and Slade.

It is a pleasure to acknowledge the extensive assistance given this work by Mr. Adam Dattner and to thank Prof. H. Alfvén for his hospitality, encouragement and the use of laboratory facilities.

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Transformation of the α- and β-Forms of Calcium Sulphate Hemihydrate to Insoluble Anhydrite

ALTHOUGH there is no difference between the X-ray diffraction patterns of α- and β-calcium sulphate hemihydrate[1], differences have been reported for density, specific heat and the heat of formation[2]. I have shown that the dehydration of each form to soluble anhydrite proceeds at about the same rate, but that the rate of transformation of soluble to insoluble anhydrite is much greater for the α-form. This is of importance in the examination of gypsum plasters, which may contain one or both of these forms according to the method of manufacture. The difference between the α- and β-forms is demonstrated here by simultaneous differential thermal and thermogravimetric analyses[3], and by determining the rate of the phase transformation at a static temperature.

Samples of α-hemihydrate were prepared by heating a pure precipitated gypsum in concentrated nitric acid[1], in a saturated steam atmosphere[2], and in a concentrated solution of magnesium sulphate[4]. Samples of β-hemihydrate were prepared by calcining the same gypsum in open dishes in an air oven at 150°, 200° and 240° C. The differential thermal curve for α-hemihydrate (Fig. 1, curve *a*) indicates the rapid formation of insoluble anhydrite by a sharp exothermic peak at 255° C. The form of the curve was the same for a large number of samples prepared by the methods outlined above. Although in some instances a reduction in the size of the exothermic peak was noted, the claim by Budnikov and Kosyreva[5], that the differential thermal curve for α-hemihydrate shows no exothermic effect, is not in agreement with my results. The simultaneous thermogravimetric curve showed that the water content of the sample was about 0·1 per cent when the exothermic reaction commenced, and X-ray examination of the sample heated to 290° C. (the end of the exotherm) showed that it contained about 60 per cent insoluble anhydrite. Further conversion of the α-soluble anhydrite to insoluble anhydrite took place slowly between 290° and 550° C., with a loss of about 0·05 per cent of water. The β-hemihydrate behaves differently. The differential thermal curve (Fig. 1, curve *b*) indicates a gradual transformation to insoluble anhydrite commencing at about 300° C. The simultaneous thermogravimetric curve indicates that at 300° C. (the beginning of the exotherm) the water content was reduced to about 0·2 per cent, and X-ray examination of the sample heated to 500° C. (the end of the exotherm) showed that it was almost pure insoluble anhydrite. By comparison, it should be noted that in the decomposition of the α-hemihydrate a small amount of soluble anhydrite still remained at 500° C.

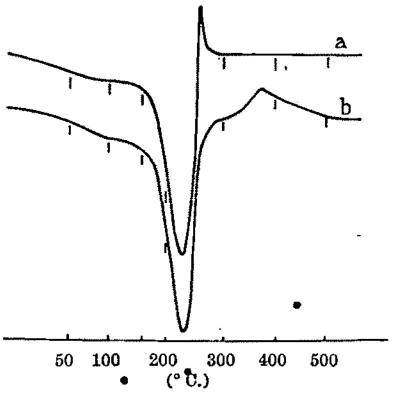

Fig. 1. Differential thermal analysis curves for calcium sulphate hemihydrate. *a*, α-form ; *b*, β-form

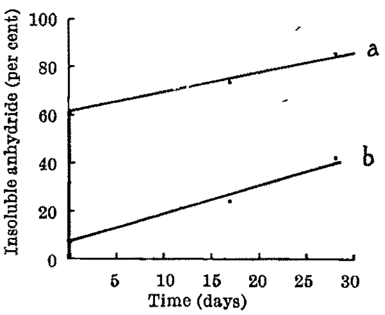

Fig. 2. Rate of formation of insoluble anhydrite from calcium sulphate hemihydrate at 200° C. *a*, α-form ; *b*, β-form

In a mixture containing α- and β-hemihydrate the exothermic peak of the α-form is often not visible on the differential thermal curve because it is masked by the endotherm of the β-form, which is not complete until about 300° C. ; but the form of the curve is still different and the area of the exothermic peak due to the β-form is significant. It is reduced to about half its normal size in a mixture of equal parts of α- and β-hemihydrates, and can therefore give an indication of the proportion of each form present. The area of each exothermic peak of β-hemihydrate was not appreciably different for samples prepared by heating at 150° C. for 4 hr., at 200° C. for 1 hr., and at 240° C. for 45 min.

The phenomena observed under dynamic heating conditions were also observed at a static temperature of 200° C. Fig. 2 shows that initially the rate of transformation of the α-form to insoluble anhydrite is about eight times greater than that for the β-form, but thereafter the rate decreases to about half that of the β-form.

I wish to thank Dr. W. F. Cole for taking the X-ray photographs.

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Estimation of Strontium in Biological Materials by means of a Flame Spectrophotometer

PREVIOUS attempts to determine the strontium content of biological materials by spectrochemical methods have not been entirely satisfactory, and in at least one investigation[1] the method was abandoned in favour of neutron activation analysis. With recent improvements in the performance of flame spectrophotometers which have been described by various authors[2] methods have been evolved for the assay of calcium and magnesium which claim a high accuracy.

Need has arisen in this laboratory for a rapid and reliable means of estimating strontium in biological material as a result of the continued study of the turn-over of strontium in man and experimental animals. A method, based on neutron activation analysis, has already been described[3]. Although this is regarded as both sensitive and accurate, the procedure is laborious and, in an extended metabolic study, these radiochemical estimations are time-consuming and involve carrying out the estimation in the vicinity of a nuclear pile. I have devised a rapid and accurate method for the estimation of strontium in which an *S.P.* 900 'Unicam' flame spectrophotometer is used.

(*a*) *Chemical procedure*. Since strontium is only a trace element in biological material, ranging in human plasma from about 0·03 p.p.m. to about 600 p.p.m. in human fæcal ash, some chemical treatment of the material is necessary. (The specimens should contain at least 5 μgm. of strontium.) Urine or plasma was precipitated with excess ammonium oxalate at about neutral *p*H. All solid materials such as bone, tissue or fæces were dry-ashed overnight at about 650° C. The subsequent treatment involved the removal from the ashed material of much of the alkali and phosphate, which otherwise interferes with the spectrochemical estimation of the strontium. All solids were therefore dissolved in 2 *N* hydrochloric acid. (A suitable aliquot was withdrawn at this stage for calcium estimation, which was assayed either by a modified ethylenediaminetetraacetic acid method which is shortly to be described or by means of the flame spectrophotometer.) Strontium and calcium were reprecipitated as oxalates and, after centrifuging and discarding the supernatant, the residues were dissolved in concentrated nitric acid. The concentration of nitric acid was then increased to 85–90 per cent by the addition of fuming acid. After standing in iced water for 10 min., these specimens were centrifuged and the supernatant again discarded. The insoluble nitrates (mainly of calcium and strontium) were then dissolved in water and made up to a concentration of between 1 and 5 p.p.m. in strontium in a suitable volumetric flask (25 or 50 ml., say).

(*b*) *Spectrophotometric assay*. A known aliquot, say 0·1 ml., of a standard strontium solution containing 200 p.p.m. of 'Specpure' strontium was placed in a 10-ml. volumetric flask and this was then filled to the mark with the nitrate extract already prepared. An internal standard is thus obtained and the two solutions were assayed directly on the flame spectrophotometer using the strontium line at 460·7μ, a slit-width of about 0·05 mm. and a gain setting of about 5. Deflexions were recorded on a galvanometer.

In order to eliminate any interference from calcium or other ions on the strontium readings, the galvanometer deflexion was also observed at about 5μ on either side of the strontium wave-length. These settings gave zero deflexions on a pure strontium solution but usually small deflexions were observed in the case of tissue or excreta extracts. The mean deflexion, φ, which was regarded as a white radiation background, was subtracted from the two deflexions θ_1 and θ_2, θ_1 corresponding to the unknown solution of strontium content X and θ_2 to the second solution. Then, if C denotes the known addition of strontium made :

$$\frac{X + C}{X} = \frac{\theta_2 - \varphi}{\theta_1 - \varphi} \text{ or } X = \frac{(\theta_1 - \varphi)C}{\theta_2 - \theta_1}$$

provided the galvanometer readings so corrected are proportional to the concentration of strontium. This condition was verified using a variety of concentrations over the range 0–10 p.p.m. Table 1 shows the comparison between the strontium content for various samples as determined on the spectrophotometer with that determined by neutron activation.

Table 1

Specimen	Strontium content Flame photometer	 Neutron activation
Fæcal ash 1	7·28 mgm./day	7·23 mgm./day
Fæcal ash 2	5·28 ,, ,,	5·45 ,, ,,
Fæcal ash 3	5·72 ,, ,,	5·45 ,, ,,
Urine oxalate 1	0·137 ,, ,,	0·153 ,, ,,
Urine oxalate 2	0·187 ,, ,,	0·188 ,, ,,
Cow's milk ash 1	36 p.p.m.	35 p.p.m.
Cow's milk ash 2	49 ,,	37 ,,
Diet ash	74 ,,	80 ,,

This comparison is illustrative of the general agreement which we have obtained between the two methods. It is concluded that the error as deduced from such comparisons as shown in Table 1 and from the reproducibility of individual determinations is between 2 and 3 per cent at strontium concentrations of about 2 p.p.m.

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Observation of Transient Intermediates in Redox Processes by Variable Voltage Oscillo-polarography and Cyclic Voltammetry

THE dropping mercury electrode can be used for oscillo-polarography[1] but the oscillo-polarograms obtained during the investigation of organic compounds are often difficult to interpret.

Recent work in this laboratory has led to the development of a 'hanging' mercury drop electrode which has proved of value in the analysis of both inorganic and organic solutions[2,3]. This electrode yields oscillo-polarograms in which a clear and stable image is produced and any desired potential between 0 and − 2 V. can be applied. This feature, in combination with the possibility of using current of any frequency, makes interpretation of the results much easier and also permits the observation of the existence in solution of short-lived intermediates which do not appear in ordinary polarograms.

Some results which confirm this are shown in Fig. 1, the solution employed being a 2×10^{-4} *M* *p*-nitroaniline in 0·1 *N* potassium hydroxide.

The curves shown on the right-hand side of the diagram are (1) the polarograms obtained by use of the dropping electrode, and (2) the hanging drop cyclic voltammetric curves. In the latter it is seen that the first reduction cycle shows only the peak corresponding to the polarographic wave (1).

This corresponds to the following reduction :

$$NH_2C_6H_4NO_2 + 6e + 6H^+ \rightarrow NH_2C_6H_4NH_2 + 2H_2O;$$

in the first, and subsequent oxidation cycles, however, a minimum at − 0·06 V. is seen and this corresponds to the oxidation :

$$NH_2C_6H_4NH_2 - 2e - 2H^+ \rightleftharpoons NHC_6H_4NH$$

This reaction is reversible and so, in the subsequent reduction cycles, a peak is observed at about −0·10 V. The above mechanism is supported by our finding that the curves obtained for *p*-phenylenediamine are identical with those discussed here.

The corresponding oscillo-polarograms are shown on the left-hand side of the diagram. The span of the widest curves (7) and (8) corresponds to − 1·8 V., the current being of 50 cycles/sec. Trace (7) corresponds to the cyclic trace (2) on the right-hand side of the diagram. Five 'cuts-in' are seen. Those at about − 0·1 V. correspond to the *p*-phenylenediamine/*p*-di-iminoquinone system while the six electron reduction of *p*-nitroaniline, being irreversible, corresponds to the single cut-in at about − 0·80 V. The pair of cuts-in at − 0·50 V., however, have no parallel in (2) and so must correspond to a new redox system of such low stability as to be detectable only by use of high frequency current.

This system may correspond to the reaction

$$NH_2C_6H_4NO - 2e + 2H^+ \rightleftharpoons NH_2C_6H_4NHOH$$

the nitrosoaniline being derived, possibly, from the incomplete reduction of nitroaniline under oscillo-polarographic conditions. The evidence for this supposition is not very strong and further attempts at identification are in progress. Nevertheless, the cuts-in undoubtedly correspond to short-lived species and so it is evident that the method shows promise in such studies.

The traces (3) to (6) illustrate the use of selected applied voltages and the way in which the results can be of value in the interpretation of results. For example, the cuts-in near − 0·1 V. are not observed until the applied voltage reaches − 0·6 V. Thus, these cuts-in are positively identified with the products of the six electron reduction of *p*-nitroaniline. Further evidence is then obtained by comparison with (8), which shows the oscillo-polarogram of *p*-phenylenediamine.

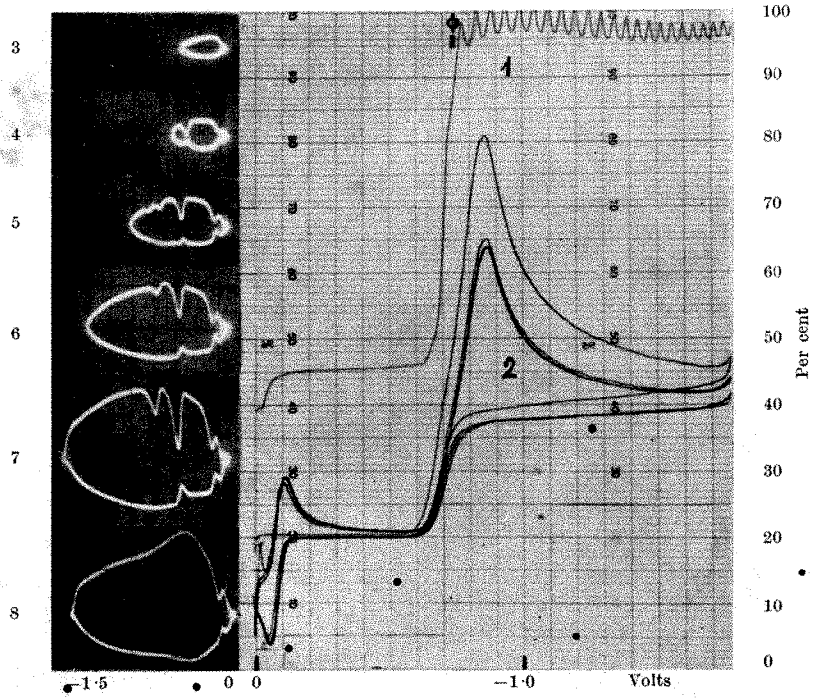

Fig. 1

It is evident that variable voltage oscillo-polarography with the hanging drop electrode offers considerable advantages in the interpretation of the sometimes very complicated traces which are often obtained with reducible organic solutions[3], and constitutes a new method of studying the properties of transient intermediates.

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Standard Potential at 25° C. of the Silver–Silver Chloride Electrode in Formamide

FORMAMIDE is a very good solvent for many strong and medium weak acids. In order to determine their dissociation constants accurately by potentiometric measurements it is necessary to know the standard potential of a reference electrode with respect to the normal hydrogen electrode. Until recently, only the value of the cadmium–cadmium chloride electrode has been given in the literature[1]. We have been able to determine the standard potential of the silver–silver chloride electrode by the classical method using the following cell without liquid–liquid junction :

$$Pt, H_2/HCl(HCONH_2)/AgCl, Ag$$

Platinum electrodes were prepared according to Jones[2] and the silver–silver chloride electrodes by the electrolytic method[3,4]. (Both types of electrodes were reproducible within 0·5 mV.)

The potential E of this cell depends on the molality of hydrochloric acid, its mean activity coefficient and the standard electrode potential $E°$. The value of $E°$ may be found by using Hitchcock's method[5], which consists in extrapolating the auxiliary function $E' = E + 2k \log m - 2kAm^{1/2}$ to $m = 0$. Here $k = 2{,}3026 \cdot RT/F$ and $-Am^{1/2}$ is the first Debye–Hückel approximation of the logarithm of the mean activity coefficient. In the case of formamide, with dielectric constant[6] at 25° C. equal to 109·5, $2kA$ is equal to $3 \cdot 65 \times 10^{-2}$.

In all our experiments, the formamide ('Fluka', purum) was purified by vacuum distillation followed by two crystallizations and a fractional fusion. The physical constants of our final product ($T_f = 2{\cdot}9°$ C.; $n_D^{25} = 1{\cdot}4458$; $\varepsilon^{25} = 109{\cdot}5$) were in excellent agreement with the best values given in the literature[6, 7].

Solutions obtained by passing dry gaseous hydrogen chloride into the formamide could not be stored, even in an inert atmosphere. Decomposition of these solutions is probably due to hydrolysis of formamide by very small traces of water, this reaction being catalysed by hydrogen chloride[8]. Every solution used in the determination of $E°$ was therefore prepared directly in its cell immediately before measuring the potential, and the equilibrium values of these potentials, which changed slightly with time, were extrapolated to zero time. Nevertheless, the determination of the standard potential remained difficult as the preparation of the solutions was critical. Owing to the instability of the solutions, accuracy was not better than 1 mV. The molalities used ranged from $2{\cdot}38 \times 10^{-3}$ to $5{\cdot}164 \times 10^{-2}$.

Extrapolation of E' values by the method of least squares gave the following value for the standard potential (Fig. 1):

$$E° = 0{\cdot}204 \pm 0{\cdot}002 \text{ V.}$$

($0{\cdot}002$ is the mean standard deviation of the experimental points with respect to the calculated line.)

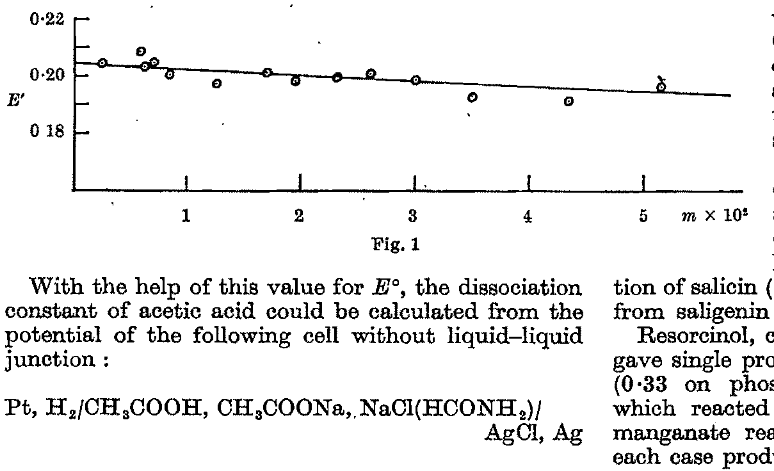

Fig. 1

With the help of this value for $E°$, the dissociation constant of acetic acid could be calculated from the potential of the following cell without liquid–liquid junction:

$$\mathrm{Pt,\ H_2/CH_3COOH,\ CH_3COONa,\ NaCl(HCONH_2)/AgCl,\ Ag}$$

Using the method of Harned and collaborators[9], we found $\log K_a = -6{\cdot}81 \pm 0{\cdot}01$ at 25° C., corresponding to a value[10] of the acidity function X equal to $0{\cdot}578$. This is in good agreement with the value predictable from those of other carboxylic acids in formamide and the X value of acetic acid in water[11].

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Metabolism of Phenolic Compounds by the Broad Bean *Vicia faba*

PHENOLIC glycosides are common constituents of plant tissues but little is known about the biosynthesis of the glycosidic bond in these compounds. Bourquelot and Hérissey synthesized (*o*-hydroxybenzyl)-β-glucoside by incubating glucose with saligenin in the presence of emulsin[1], but it is unlikely that transglycosylation of this type is an important mechanism for the biosynthesis of glycosides *in vivo*. The formation of aryl glucosides by leaf disks infused with various phenols has been reported by Miwa *et al.*[2] and it appears that glucose-1-phosphate is involved in these reactions.

The stems of young bean shoots were immersed in aqueous solutions containing glucose (0·5 per cent (w/v) and a phenol (0·5 per cent w/v) and after 48 hr. the tissues were extracted with methanol and the extracts examined on paper chromatograms (butan-1-ol/ethanol/water (4 : 1 : 5, organic layer) solvent: ammoniacal silver nitrate[3], diazotized *p*-nitroaniline/sodium hydroxide[4] and periodate–permanganate[5] spray reagents). Some of the products were isolated in small amounts by chromatography on Whatman No. 3 paper and afterwards hydrolysed by an emulsin preparation.

The feeding of quinol and phloroglucinol gave rise to products which co-chromatographed with arbutin (R_F 0·44) and phlorin (R_F 0·35) respectively, and gave the same colour reactions with the diazo reagent as the authentic glycosides. Similarly, the compound obtained by feeding saligenin was indistinguishable from (*o*-hydroxybenzyl)-β-glucoside, and hydrolysis with emulsin yielded saligenin and glucose, this being further evidence for the presence of a β-glycosidic linkage. No evidence for the formation of salicin ((*o*-hydroxymethylphenyl)-β-glucoside) from saligenin could be obtained.

Resorcinol, catechol and hydroxyhydroquinone all gave single products (R_F values 0·51, 0·64 and 0·43 (0·33 on phosphate-buffered paper) respectively), which reacted with the diazo- and periodate-permanganate reagents. Hydrolysis with emulsin in each case produced glucose together with the phenol which had been administered to the shoot.

These results suggest that the mono-β-glucosides of catechol and resorcinol had been produced. The product obtained from hydroxyhydroquinone was probably (3,4-dihydroxyphenyl)-β-glucoside, as it showed a decreased rate of movement when subjected to chromatography on buffered paper, this being evidence for the presence of an *ene-diol* grouping[6]. Small amounts of an electrophoretically and chromatographically identical compound were also formed when young bean shoots were allowed to take up a solution of arbutin (1 per cent w/v). In this case, the arbutin was presumably hydroxylated by polyphenol oxidase.

Glucoside formation could not be demonstrated when phenol was used as a substrate and only traces of possible glucosides were produced using pyrogallol.

The biosynthesis of the glucosides was confined chiefly to the leaves and the activity was completely destroyed by grinding these tissues in the presence of 0·1 *M* phosphate buffer (*p*H 6·0). The synthetic activity of the isolated stems was negligible.

During the preparation of this communication, Hutchinson, Roy and Towers[7] reported glucoside formation by apple-leaf and leaves from a number of other plant species, when fed with phenols in the presence of D-glucose-^{14}C.

This study is being continued to determine the exact mechanism of formation of glucoside in the plant and to examine the biosynthesis and metabolism of the more complex phenolic glycosides containing two or more sugar units.

The interest shown by Prof. E. J. Bourne is very much appreciated.

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A Paper Chromatography Method for the Determination of Suitable *p*H Values for the Extraction of Antibiotics

EXTRACTION methods are usually used for the isolation and purification of antibiotics soluble in organic solvents which are immiscible with water. This method can be applied if the partition coefficient of the antibiotic between the solvent and water is sufficiently large. The partition coefficient often depends on the *p*H value, particularly for acidic or basic compounds.

We have worked out a method for determining suitable conditions for the extraction of antibiotics by a *p*H chromatogram with the help of which we can also investigate the ionic character of the antibiotics. We use *p*H chromatograms when only cultures of the antibiotically active micro-organisms on Petri-dishes are available, that is, even before the crude substances have been isolated.

To prepare *p*H chromatograms we determine the solubility of the compounds by paper chromatography in 10 solvents[1]: distilled water, 3 per cent ammonium chloride (w/v), methanol, acetone, ethyl acetate saturated with water, *n*-butanol saturated with water, ether saturated with water, chloroform, benzene, petrol ether. Agar plugs, diameter 10 mm., cut from the micro-organism colonies, are placed 4 cm. from the lower end of 20 cm. × 1 cm. strips of Whatman No. 1 filter paper. After 15–30 min. the plugs are removed, the strips are dried in air, and chromatographed by the ascending technique using the solvents mentioned. After chromatographing, the strips are dried in air and placed on the surface of agar plates seeded with a suitable test-organism and detected bioautographically in the usual manner. After this, coloured prints on filter paper of the inhibition-zones can be obtained by our method[2].

The *p*H chromatograms are prepared as follows: nine sheets of Whatman No. 1 paper are buffered with McIlvain citrate–phosphate buffers of *p*H 2·2, 3, 4, 5, 6, 7 and 8 and with phosphate buffers of *p*H 9 and 10. After drying in air 20 cm. × 1 cm. strips of the buffered papers are cut, and the starting line and the upper line of the ascending solvents are marked 4 cm. and 19 cm. respectively from the lower end of the papers.

We use one strip of each of the nine buffered papers for the chromatography of every antibiotic. Agar plugs are put on the papers in the same way as was described for the method of selecting a suitable solvent. All nine strips are then chromatographed in the solvent which proved to be the most suitable. Development is stopped when the solvent front reaches the line 15 cm. from the start. After drying the chromatograms in air the bio-autographical detection method is used in the usual way.

The positions of the spots on the *p*H chromatograms are characteristic for every antibiotic. Acidic substances give spots farther from the starting line when chromatographed on papers buffered in the acidic range; the higher the *p*H the smaller the distance of these spots from the starting line. With basic substances the reverse is true. The distances of spots of neutral antibiotics are unaffected by *p*H. In this way the ionic character of an antibiotic can be determined from the overall characteristics of a complete *p*H chromatogram.

Among other things, the R_F values depend on the partition coefficient of the antibiotic between the mobile phase (organic solvent) and the non-mobile phase (water on paper)[3]. The extraction of a compound will be most successful at the *p*H value where this partition coefficient is greatest, that is, where the antibiotic spot on the *p*H chromatogram is farthest from the starting line. On the other hand, re-extraction from the organic solvent to water will proceed best at the *p*H value where the antibiotic spot remains on the starting line, that is, the *p*H at which it is most insoluble in the solvent used.

We have tested our method on a number of commercially available antibiotics using the solvents which are used in their industrial production. The results in all cases indicated extraction procedures absolutely identical with those applied in industry. A more detailed paper on this method will be published later[4].

As an example, a *p*H chromatogram of benzylpenicillin, developed by using amylacetate, is shown in Fig. 1. The appearance of the *p*H chromatogram confirms the acidic character of this compound and

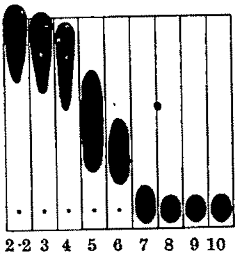

Fig. 1

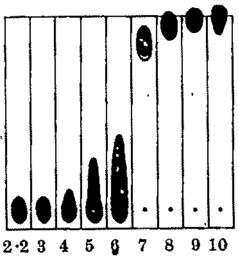

Fig. 2

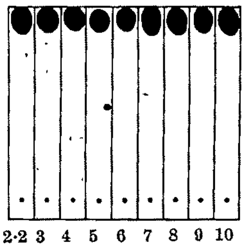

Fig. 3

Fig. 1. *p*H chromatogram of benzylpenicillin developed in amylacetate. Test organism, *Bacillus subtilis SDPC* 1 : 220

Fig. 2. *p*H chromatogram of erythromycin developed in amylacetate. Test organism, *Bacillus subtilis ATCC* 6633

Fig. 3. *p*H chromatogram of chloramphenicol developed in ethylacetate. Test organism, *Bacillus subtilis ATCC* 6633 indicates that the extraction of penicillin from water to amylacetate will be best at about pH 2. Similarly, the re-extraction from amylacetate to water will be best at pH 8. These results agree with known extraction and purification methods[5].

Figs. 2 and 3 show pH chromatograms for a basic antibiotic, erythromycin, and a neutral one, chloramphenicol. For erythromycin pH 9 and pH 4 are most suitable for extraction and re-extraction respectively[5]. The extraction of chloramphenicol is unaffected by pH [5,6].

This method has proved to be very helpful in research on new antibiotics.

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Exogenous Sources of Urinary Phenol and Indole Acids

THE phenol and indole acids of human urine have been examined following the ingestion of bananas or coffee. Bananas were tested because of a report that they contain serotonin, norepinephrine, dopamine and possibly 3,4-dihydroxyphenylalanine[1]. Coffee was investigated because of an observation that vanillic acid is excreted following the ingestion of caffeic acid, but not coffee[2], and a suggestion that the excretion of vanillic acid may be related to norepinephrine metabolism and stress[3].

Two healthy adults were placed on a high-protein diet from which materials of plant origin were excluded in order to minimize the excretion of exogenous phenol and indole acids. Control urines were collected for 6 hr. on the second and third days. One subject then ingested 4 bananas (480 gm.) and the other 1,000 ml. of coffee percolated from 64 gm. of commercial, ground, roasted coffee beans. Urines were collected for the following 0–7 and 7–15 hr. periods. Extraction and two-dimensional paper chromatography were carried out as described previously[4,5]. The changes observed in the pattern of urinary phenol and indole acids are summarized in Table 1. The amounts of 5-hydroxyindoleacetic, 3-methoxy-4-hydroxy-D-mandelic and 3-methoxy-4-hydroxyphenylacetic acids were determined on paper chromatograms by visual comparison of spots obtained from appropriate aliquots of banana urine extracts and the authentic compounds.

It has been pointed out that measurement of urinary 5-hydroxyindoleacetic acid after ingestion of bananas could result in a diagnosis of carcinoid tumour[6]. The data in Table 1 show that excretion of this serotonin metabolite increased sharply in the first 7 hr. after ingestion but soon returned to normal. The diagnosis thus might vary with the time and duration of the urine collection after ingestion of bananas. The possibility of a diagnosis of pheochromocytoma also has been suggested[1]. The excretion of 3-methoxy-4-hydroxy-D-mandelic acid increased after ingestion of bananas, but the normal range[7] was not exceeded; if the output of this substance is used as an index of norepinephrine metabolism[7], an erroneous diagnosis is therefore unlikely. The excretion of 3-methoxy-4-hydroxyphenylacetic acid, which is a metabolite of 3,4-dihydroxyphenylalanine and dopamine, also remained within the normal range[8] after ingestion of bananas.

No other 5-hydroxyindole acids were detected in the banana urine extracts, even when volumes equivalent to 4 mgm. of creatinine were chromatographed. The occurrence in bananas of at least two 5′-hydroxyindoles besides serotonin has been mentioned[1]. The excretion of indoles No. 14 and 15 increased after banana ingestion; these compounds frequently are present in urines from institutionalized patients[5], but also have been observed in some normal urines.

The same m-hydroxyphenyl and 3-methoxy-4-hydroxyphenyl acids which were excreted after coffee (Table 1) also were detected in urine extracts

Table 1. PAPER CHROMATOGRAPHY OF URINARY INDOLE AND PHENOL ACIDS AFTER INGESTION OF BANANA OR COFFEE*

Compound No.†	Urinary acid	Banana			Coffee		
		Control	0–7 hr.	7–15 hr.	Control	0–7 hr.	7–15 hr.
Indole							
1	5-Hydroxyindoleacetic	3·0 mgm./day	13·2 mgm.	0·79 mgm.	++	++	++
2	Indoleacetic	+++	+++++	+++	+++	+++	+++
10	N-Acetyltryptophan	0	0	0	0	+++	+
14	Unidentified	+	++	++	0	0	0
15	Unidentified	+	++	++	0	0	0
Phenol							
2	m-Hydroxyphenylhydracrylic	0	0	+	+	+	++++
3	m-Hydroxyhippuric	+	+	+	+	+	+++
7	3-Methoxy-4-hydroxyphenylacetic	3·3 mgm./day	1·00 mgm.	1·54 mgm.	+	+	+
8	Unidentified	0	0	0	0	++	+
10	3-Methoxy-4-hydroxy-D-mandelic	2·3 mgm./day	0·40 mgm.	0·19 mgm.	+	+	+
11	m-Hydroxyphenylacetic	0	0	++	0	0	0
12	p-Hydroxybenzoic	+	+++	+++	+	++	++
16	Feruloylglycine	0	+	0	0	++	++++
17	Vanilloylglycine	0	+	0	0	+	++
18‡	3-Methoxy-4-hydroxyphenylhydracrylic	0	0	0	0	++	++++
19	Vanillic	0	0	0	0	+++	+
20	Dihydroferulic	0	0	0	0	+	+++
21	m-Hydroxyphenylpropionic	0	0	0	0	0	+
31‡	Ferulic	0	0	0	0	+	++
34	Unidentified	0	0	0	0	0	+
37	Unidentified	0	0	0	0	+++	+

* One + represents a spot diameter of $\frac{1}{4}$ in. The total amount of 5-hydroxyindoleacetic, 3-methoxy-4-hydroxy-D-mandelic, and 3-methoxy-4-hydroxyphenylacetic acids in each banana urine extract is corrected for endogenous excretion, which was determined from control urines.

† Numbers refer to chromatographic maps of urinary phenols (ref. 4) and indoles (ref. 5).

‡ These compounds give blue spots with p-dimethylaminobenzaldehyde after several hours, and are probably the ones designated as indoles No. 11 and 28 in a previous report (ref. 5).

after ingestion of caffeic or ferulic acids. The results differ in some respects from those of Booth *et al.*[2], who first reported the unusual formation of these groups of metabolites from caffeic and ferulic acids. These workers noted that only *m*-hydroxyhippuric acid and *m*-coumaric glucuronide, and none of the other caffeic acid metabolites, were excreted after ingestion of 'instant' or caffeine-free 'soluble' coffee. Their observation of fewer metabolites may reflect a loss or change of some components during manufacture of 'soluble' coffee. The hydracrylic acids (phenols No. 2 and 18) were not recorded as metabolites by Booth *et al.*[2]. These compounds are converted easily to the corresponding acrylic acids, however, and could have been destroyed under the different conditions of processing.

Vanillic acid and the other related exogenous 3-methoxy-4-hydroxyphenyl acids have been observed in many human urines[4]. Metabolic precursors are also present in plant materials other than coffee, such as fruits and vegetables[2], and natural vanilla flavour is added to some commercial foods. A suggestion that, on an unrestricted diet, the excretion of vanillic acid may be related to norepinephrine metabolism and stress[3] therefore seems unjustified.

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Rennin Coagulation of Enzymatically Dephosphorylated Casein

MANY of the properties of milk depend on the existence of large aggregates of casein[1], the 'molecular' weights of which are in the region of 10^6. When calcium-binding substances such as citrate or oxalate are added, these aggregates are rapidly reduced in size[2] to a 'molecular' weight of about 10^5, the specific value being highly dependent on *p*H, temperature and ionic strength[3]. The mechanism whereby calcium effects the formation of the aggregates is unknown, but it has often been assumed that the first step is combination with the phosphate groups of casein, and it has been suggested[4] that the calcium ions might cross-link adjacent casein molecules. In recent years it has been found that various phosphatases will catalyse the removal of phosphate groups from casein under mild conditions of *p*H and temperature[5,6]. Thus enzymatic dephosphorylation should be a useful tool in studying the role of casein-bound phosphate in the reactions of milk dependent on calcium. The clotting of milk by the enzyme rennin is dependent on calcium[1], and is a reaction which lends itself to precise study.

Several phosphatases were investigated; potato phosphatase was chosen for its apparent freedom from proteinases and for its ability to act on casein as it exists in milk, as well as on solutions of isolated casein. This phosphatase was purified by a slight modification of Kornberg's method (Horecker, B. L., private communication). The final preparation had a specific activity of $1 \cdot 7 \times 10^5$ units/mgm. protein and showed a 1,200-fold increase (on a protein basis) over the original extract. (One unit releases 1 μgm. phosphorus/hr. from *p*-nitrophenyl phosphate in the following conditions: 0·02 M substrate; 0·08 M acetate buffer (acetic acid/sodium acetate), *p*H 5·0; 0·004 M magnesium chloride; incubated at 37° C. A solution containing 1 gm. bovine albumin per dl. was used as a diluent for the enzyme.)

Preliminary studies showed that the rennin coagulation-time of milk could be increased markedly by treatment with potato phosphatase. In some experiments coagulation did not occur even after 100 times the normal amount of rennin had been added. It was then decided to make a quantitative study of this phenomenon, and for this purpose it was thought advisable to work with isolated casein. In order to obtain reproducible results it was necessary to follow a carefully controlled procedure both in the preparation of dephosphorylated casein and in the measurement of rennin coagulation-times. Depending on the degree of dephosphorylation desired, varying amounts of phosphatase (200–1,000 units per ml. of casein solution) were added to a 5 gm./dl. solution of bovine casein (prepared by the method of Van Slyke and Baker[7]), which was then incubated at 37° C. (Solution of the casein was achieved by the slow addition of 0·2 N sodium hydroxide to a suspension of the casein in distilled water; the *p*H did not exceed 8 in the process, and the final *p*H was 6·8.) After 0–5 hr., an aliquot was removed for the assay of inorganic phosphate, and the remainder was diluted with 8 volumes of cold (0–5° C.) distilled water and precipitated by the slow addition of 1 M acetic acid. The precipitate was separated by filtration through a sintered glass funnel, then washed 2–5 times with cold distilled water, twice with cold (−13° C.) 95 per cent ethanol and twice with cold (−13° C.) ether. Finally, it was ground in a mortar and dried *in vacuo* over calcium chloride. The product was free from phosphatase activity. For studying their coagulation by rennin, the samples of dephosphorylated casein were dissolved as before to give a solution of 0·3 gm./dl. and then twice dialysed for at least 2·5 hr. at 0–5° C. against 18 volumes of a *p*H 6·8 buffer[8] containing $3 \cdot 66 \times 10^{-2}\ M$ cacodylic acid, $2 \cdot 94 \times 10^{-2}\ M$ triethanolamine, and sufficient calcium chloride to give the desired concentration of calcium. After dialysis the solutions were diluted with buffer to give a final concentration of protein of 0·24 gm./dl. Coagulation times[9] were measured on duplicate samples after 10–15 min. equilibration at 30° C. Crystalline rennin from calves was used (Ernstrom, C. A., unpublished work).

Fig. 1 shows the results obtained with one set of samples of dephosphorylated casein. As the percentage dephosphorylation is increased, the time required for coagulation by rennin first increases and then passes through a maximum. The same behaviour is observed at all three levels of calcium, but the effect is more striking at the lower levels. No coagulation was observed in 0·011 M calcium chloride for the samples with intermediate degrees of dephosphorylation. Another set of samples of dephos-

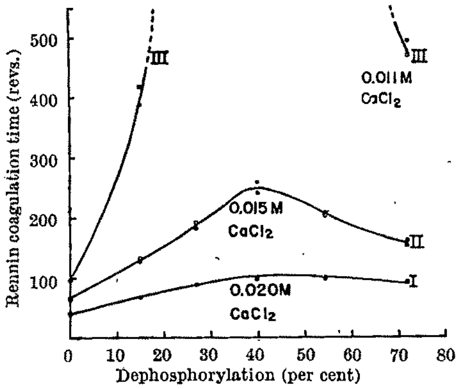

Fig. 1. The relation between percentage dephosphorylation of of bovine casein and the time required for clotting by rennin, at three concentrations of calcium. 10 ml. of casein solution was brought to the temperature of the bath (30° C.), and 1 ml. of rennin ($5 \cdot 6 \times 10^{-4}$ mgm. of rennin nitrogen) was added. Samples were rotated at 16·2 r.p.m. The concentrations of calcium given are those of the buffers against which the samples were dialysed

phorylated casein showed the same behaviour as that in Fig. 1 but gave slightly different values for the coagulation-times. The fact that the curves pass through a maximum suggests that more than one effect of dephosphorylation is present; it is likely that the increase in isoelectric point on dephosphorylation tends to produce shorter coagulation times.

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'Solubilization' of a Cytochrome *b* Component from *Micrococcus lysodeikticus*

IN an earlier communication[1] we reported some preliminary observations on a cytochrome *b* component of *Micrococcus lysodeikticus*, strain N.C.T.C. 2665. The cytochrome was separated to some extent from the cytochromes *a* and *c* which were also present, but it remained attached to particles which were thrown down by centrifugation at 20,000*g*.

In further experiments, we have found that the cytochrome can be 'solubilized' by treatment of the particulate preparation with a 1 per cent solution of 'Cetrimide' (B.P.). Centrifugation at 20,000*g* at this stage separated a small deposit which contained some cytochrome *c*. Further purification of the cytochrome *b* component was achieved by fractional precipitation from the supernatant by addition of ammonium sulphate. Between 20–40 per cent (w/v) ammonium sulphate, the small quantity of residual cytochrome *c* was precipitated. The cytochrome *b* component came down as a red, gelatinous precipitate at ammonium sulphate concentrations of 40–60 per cent (w/v). This material was apparently soluble in 0·04 *M* phosphate buffer at *p*H 7. The solution obtained was dialysed for 24 hr. against running tap-water, and during this time precipitation of a yellow pigment occurred, the absorption spectrum of which suggested that it might be a carotenoid. The maxima in petroleum ether, 415 mμ, 435 mμ and 465 mμ, corresponded to the wave-lengths recently reported[2,3]. The precipitate was filtered off and the filtrate was allowed to stand in the cold. More of the yellow pigment separated over a period of 48 hr., but no further precipitation occurred during the subsequent 72 hr.

The remaining solution was examined spectrophotometrically, after reduction by addition of solid sodium dithionite, and peaks corresponding to a cytochrome of the *b*-group were found. The absorption maxima of this component were at 558 mμ, a small peak at approximately 525 mμ and a Soret peak at 529–530 mμ; there was no evidence of residual cytochrome *c*. It appears, therefore, that the component should be regarded as a cytochrome b_1. The maximum at 558 mμ differs slightly from that found earlier with cruder preparations in glycerol, which showed a 'flat' peak extending from 560 mμ to 563 mμ. These observations have been repeated, and the slight difference has been confirmed. Whether it is due to the presence of an extra component in the crude preparations or to a slight shift due to different optical or physico-chemical conditions is not yet certain. Because of the residual light-scattering with the cruder materials, the readings were necessarily less precise than with the clear solutions which were later available.

The solutions obtained by the method described still contained some yellow carotenoid pigment which could not be extracted with petroleum ether. The pigment was, however, extractable with chloroform or butanol, but the cytochrome b_1 was damaged by this treatment.

These observations suggest that at least some of the carotenoid is conjugated with a protein, and while it is possible that this might be the protein moiety of cytochrome b_1 itself, we have no direct evidence for this.

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Occurrence of Poly-β-Hydroxybutyric Acid in Aerobic Gram-Negative Bacteria

DURING an examination of the metabolic products of an unidentified purple-pigmented pseudomonad, a fraction, soluble in chloroform and insoluble in ether, was found to comprise 30 per cent of the dry cell weight. The material was isolated as a colourless solid, m.p. 168° C., which gave on alkaline hydrolysis a 70 per cent yield of crotonic acid. (Identified by m.p., mixed m.p. and preparation of the anilide and *p*-bromphenacyl ester.) The crotonic acid could also be obtained in 60–70 per cent yield by destructive distillation of the original solid. It was thought likely that the solid was a β-hydroxybutyric acid polymeric ester and this was confirmed by infra-red spectroscopy (ref. 1 and Farmer, V. C., personal communication) and by analysis (found, per cent; C, 55·1; H, 7·1. Calculated for $(C_4H_6O_2)_n$: C, 55·8; H, 6·8). Similar polymers have been described from *Bacillus megaterium*[2], *Azotobacter chroococcum*[3] and *Micrococcus halodenitrificans*[4].

The unidentified pseudomonad (*HCC*, *B* 175)[5], which was typical of a group isolated from Trinidad soils, was stained for the presence of 'fat' by the method of Burdon[6], using an alcoholic solution of sudan black *B* (G. T. Gurr, Ltd., London). The cells were found to be intensely sudanophilic, as was the isolated polymer. A survey was then made for the presence of sudanophilic material in a wide range of bacteria grown on an agar medium containing glucose or glycerol as major source of carbon. All those which stained strongly and a number which did not stain were further examined. Shake flask cultures or cultures from a 2-litre aerated fermenter were centrifuged, and the dried cells extracted with hot chloroform. The chloroform extract was filtered into 3 volumes of ether, and the formation of a flocculent white precipitate was taken as being indicative of the presence of poly-β-hydroxybutyric acid. No organism lacking in sudanophilic substance gave this reaction, although some containing sudanophilic substance did not contain the polymer and presumably contained conventional lipids. The presence of poly-β-hydroxybutyric acid was confirmed in representative cultures by destructive distillation of the solid and isolation of crotonic acid, which was in every case obtained in 60–70 per cent yield. Some results of the survey are shown in Table 1.

Poly-β-hydroxybutyric acid was not detected in the following genera and species of bacteria: *Proteus*, *Flavobacterium*, *Aerobacter aerogenes* (2 strains), *Escherichia coli* (2 strains), *Serratia marcescens* (5 strains), *Xanthomonas vasculorum* (3 strains) and *Protaminobacter rubrum* (*NCIB* 2879). The polymer has thus far not been detected in numerous pigmented and non-pigmented pseudomonads, other than those listed in Table 1; they include *Pseudomonas aeruginosa*, *Ps. fluorescens*, *Ps. aureofaciens*[8,9], *Ps. chlororaphis* and *Ps. lemonnieri*[10].

The fact that the polymer was found in all the chromobacteria examined (Table 1) is of interest in view of the observation of Sneath[11] in a taxonomic study of *Chromobacterium*, that the mesophilic chromobacteria, especially, contain considerable deposits of 'fat'.

Root nodules of several leguminous plants were examined in addition to cultures of *Rhizobium*. Acetone-dried nodules from *Mimosa pudica* were found to contain 6 per cent of poly-β-hydroxybutyric acid. This substance was also detected in nodules of a *Pueraria* sp., but apparently in smaller amount. Crushed nodules from both plants were stained with sudan black *B* and the bacteroids found to contain much sudanophilic material.

Our survey has been confined mainly to aerobic Gram-negative bacteria. Poly-β-hydroxybutyric acid has not, however, so far been detected in *Streptomyces* or *Lactobacillus*, in the anaerobe, *Clostridium acetobutylicum*, or in several yeast-like fungi.

We have isolated from sea water a salt-tolerant Gram-negative rod capable of forming in artificial culture large quantities of poly-β-hydroxybutyric acid. We have not yet examined cultures of *Spirillum* for the presence of poly-β-hydroxybutyric acid, though the evidence of Lewis[12] on the cytology of this genus leads us to suspect that some spiral bacteria contain large deposits of this substance.

The cultural conditions affecting yields of polymer and the enzymic mechanism of synthesis are being studied further and will be reported elsewhere. It is obvious that there are many cases in the literature where deposits of poly-β-hydroxybutyric acid have been confused with true lipids or even as in the case

Table 1

Culture	Source and strain No.*	Culture medium (carbohydrate and organic nitrogen sources only)	Poly-β-hydroxybutyric polymer (percentage of cell dry weight)	Melting point (° C.)
Chromobacterium violaceum	*NCIB* 8182	2 per cent glucose/peptone (68 hr.)	37	164
Chromobacterium sp.	*HCC* Strain 1	2 per cent glucose/peptone (72 hr.)	33	167
Rhizobium sp.	From *Indigofera* sp. *HCC B*141	2 per cent mannitol/asparagine/yeast extract (69 hr.)	19	164
Rhizobium sp.	From *Pueraria* sp. *HCC B*142	2 per cent mannitol/asparagine/yeast extract (86 hr.)	57	176
Azotobacter vinelandii	University of Wisconsin. Strain *O*†	2 per cent mannitol/asparagine/yeast extract (69 hr.)	24	178
Pseudomonas solanacearum	Wilted tomato plant. Strain *F*2/2	2 per cent glycerol/peptone (36 hr.)	6·5	172
Pseudomonas solanacearum	Diseased banana plant. Strain *RE*21	2 per cent glucose/peptone (68 hr.)	30	172
Pseudomonas antimycetica (ref. 7)	*HCC B*44	2 per cent glycerol/peptone (89 hr.)	8	167
Pseudomonas sp.	Trinidad soil *HCC B*175	2 per cent glycerol/peptone (48 hr.)	31	168

Melting points quoted above are uncorrected.

* *HCC*, Hankey Culture Collection, Colonial Microbiological Research Institute, Port of Spain, Trinidad; *NCIB*, National Collection of Industrial Bacteria, Teddington, Middlesex.

† Supplied by Prof. P. W. Wilson, University of Wisconsin.

In addition to the bacteria listed above, poly-β-hydroxybutyric acid polymer has been identified in nineteen cultures of *Chromobacterium* and four of *Rhizobium*, two cultures of *Azotobacter agilis*, five cultures of *Pseudomonas solanacearum* isolated from diseased bananas in Trinidad, and in fifteen Pseudomonads related to *Pseudomonas* sp. *HCC B*175 isolated from Trinidad soils.

of *Rhizobium* with stages in the life-cycle of the organism.

We are indebted to Dr. V. C. Farmer, Macaulay Institute for Soil Research, Aberdeen, for the determination of the infra-red spectra.

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Separation of Anthocyanin and Leuco-anthocyanin in Flowers of *Camellia japonica*

Bate-Smith[1] observed that a methanol extract of white flowers of *Camellia japonica* turned red after heating with dilute hydrochloric acid. This suggests that leuco-anthocyanin is present in the white flowers. By the same procedure I found that red flowers of several horticultural varieties of *C. japonica* contained leuco-anthocyanin yielding cyanidin, as well as a glycoside of cyanidin.

A methanol-hydrochloric acid extract of red flowers of one of the varieties, Shikainami, was paper-chromatographed with the solvents butanol/concentrated hydrochloric acid/water (5 : 1 : 4, v/v) and 80 per cent formic acid/concentrated hydrochloric acid/water (5 : 1 : 4, v/v)[2]. As controls, chrysanthemin and cyanin were chromatographed on the same paper. R_F values were estimated as 0·24, 0·27 and 0·09, respectively, with the former solvent; and 0·53, 0·58 and 0·75 with the latter. The hydrolysate of the extract and cyanidin were then co-chromatographed using the second solvent. R_F values of the samples were identical, that is 0·20. No other spots of anthocyanin or anthocyanidin could be detected on the chromatograms.

The separation of leuco-anthocyanin from anthocyanin was carried out as follows. The red flowers (20 gm. fresh weight) were macerated with 150 ml. methanol and filtered. The filtrate was concentrated *in vacuo* at 30° C. until 15 ml. of a dark purplish-red syrup remained. The syrup was passed through a resin column (1·3 × 12 cm.) packed with 'Amberlite' *IRC*–120 (H form). The anthocyanin was found to be adsorbed quantitatively on the resin and the filtrate from the column was slightly orange. The filtrate was neutralized with 0·1 *N* sodium hydroxide and saturated with sodium chloride. Then it was exhaustively shaken with 30 ml. portions of ethyl acetate until the aqueous layer remained orange-brown after heating with propanol-hydrochloric acid[3]. The combined colourless ethyl acetate extracts were dried with sodium sulphate and evaporated *in vacuo* until a slightly pink-coloured residue remained. The residue was dissolved in 7 per cent hydrochloric acid and heated in a water-bath until a dark red colour appeared. The red matter was transferred by partition to a small amount of amyl alcohol, and the alcoholic layer was paper-chromatographed, in parallel with cyanidin, with formic acid/hydrochloric acid as solvent. The R_F value of the former was 0·19 (accompanied by brownish trail), and that of the latter (cyanidin) 0·20. This indicates that the leuco-pigment is sugar-free and should be regarded as leuco-cyanidin[4]. Extract of red flowers of the other variety, Somekawa, showed almost the same results.

Thus, it appears that flowers of some varieties of *C. japonica* contain leuco-anthocyanin, irrespective of their flower colours.

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Incorporation of Orotic Acid-^{14}C and Lysine-^{14}C in Regenerating Single Nerve Cells

Experiments on the cytoscale and also, by inference, on the tissue and macroscale have demonstrated that proteins, lipids and ribonucleic acid in the central nervous system are in a dynamic state[1–3]. The production and metabolism of these substances are apparently promoted by increased functional demands.

The process of peripheral nerve regeneration can be repeated several times during the life-cycle of the organism. The production of proteins, lipids and ribonucleic acid per nerve cell has been studied by quantitative cytochemical methods during regeneration in hypoglossal cells[4]; the latent out-growth and maturation period could clearly be distinguished cytochemically. The results reported here demonstrate the incorporation of lysine-^{14}C into the nerve-cell proteins, and orotic acid-^{14}C into the ribonucleic acid of nerve cells during regeneration.

Nerve cells belonging to the hypoglossal nucleus in rabbits were used. The nerve was crushed with cooled forceps and 0·01 mc. L-lysine-^{14}C or orotic acid-^{14}C was injected intracisternally. The rabbits treated with lysine were killed 30 min. after the injection, and the others 24 hr. after the administration of orotic acid. The nerve cells were sampled by dissecting by hand under a preparation microscope. Fig. 1 shows some fresh hypoglossal cells, dissected out and photographed in the phase-contrast microscope. Five to ten cells were used for each measurement. The cells were transferred rapidly from the fresh tissue to 0·25 *M* sucrose, freed from surrounding glial cells, placed on a holder and treated with 1 *N* cold perchloric acid for 30 sec., and carefully washed and dried. The hypoglossal control cells then weigh on average 2,200 µµgm., that is 2,000 µµgm. protein and about 10 per cent ribonucleic acid. The activity was measured with a special Geiger microtube with a window thickness of 1·5 mgm./cm.^{2}, provided

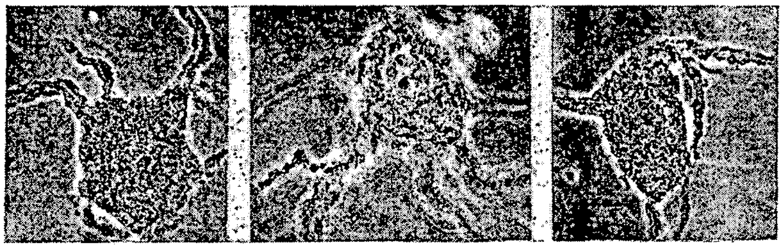

Fig. 1. Fresh hypoglossal cells from the rabbit photographed in the phase-contrast microscope in 0·25 *M* sucrose. Note the synaptic knobs as small granules on the surface of the cells

with an anti-coincidence shield. The background activity of the tube at the measuring was only 1 count/min. The results obtained are related below to those found in the quantitative study on the same type of material[4].

During the 'latent period' a small part of the nerve close to the site of the crush degenerates. The amount of protein per nerve cell was found to decrease by 30–40 per cent during this stage. The cell volume began to increase, and morphologically chromatolytic areas could be found within the cell. The incorporation of lysine-^{14}C into regenerating cells exceeded that into control cells by 70 per cent (Table 1).

Table 1. Uptake of Lysine-^{14}C by Regenerating Isolated Nerve Cells

Days after operation	Activity ratio operated cell/control cell
2	1·7
9	3·2
21	1·5
207	1·4

Lajtha *et al.*[2] and Furst *et al.*[5] have pointed out that lysine is especially useful in the study of brain proteins. In experiments of short duration the incorporation into rapidly metabolized proteins is primarily measured. The presence of free lysine can be expected to influence the result slightly, but it is important to note that this factor does not affect the conclusion that the activity found in our experiments is a measure of the metabolic activity of the cell proteins.

The protein decrease per cell and the increased incorporation of lysine into the cell proteins show that the protein loss during the latent period is not compensated by intracellular production, in spite of increased protein synthesis.

During the next stage, 3–12 days after the crush, the thin axons rapidly grow out to re-establish contact with the effector organ. This 'out-growth period' is characterized by a 100 per cent increase in the proteins per cell. The incorporation of lysine into the regenerating cells was found to increase by 200 per cent. During the same period no significant change occurred in the amount of ribonucleic acid per cell; this remained at 200 $\mu\mu$gm. But a most significant alteration occurs in the aggregation of the cytoplasmic ribonucleic acid which becomes finely dispersed, with the typical appearance of chromatolysis. During the first day after the crush no difference in the orotic acid-^{14}C incorporation was found in control and regenerating nerve cells. On the eighth day, however, when chromatolysis was pronounced, the incorporation increased by 100 per cent in the regenerating cells.

Thus, the nerve cell showing typical retrograde changes during regeneration is characterized by an intracellular concentration decrease and a considerable increase in the rate of protein metabolism. Furthermore, the orotic acid incorporation and the change in aggregation of ribonucleic acid indicate that the ribonucleic acid of the chromatolytic nerve cell is transformed from a less active to a more active form.

During the 'maturation period' the size of the axon increases. The incorporation of lysine indicates that the increase in protein metabolism per nerve cell will continue during this stage. Fischer *et al.*[6] found that regenerating hypoglossal cells 14 days after a nerve crush incorporated more methionine-^{35}S per unit area than did the control cells.

A detailed account of the experiments will be published elsewhere. The studies have been supported by grants from the Rockefeller Foundation and from the Swedish Medical Research Council.

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Influence of Linoleic and Linolenic Acids on Symptoms of Vitamin E Deficiency in Chicks

EXUDATIVE diathesis and encephalomalacia, two of the outstanding symptoms of vitamin E deficiency in chicks, are much promoted by dietary polyenoic fatty acids[1,2]. It has recently been shown[3] that, in certain circumstances, the former can occur even when the diet is free from polyenoic fatty acids; further, it can be prevented by a trace of 'Selenite'[4,5]. To our knowledge, encephalomalacia has never been observed with diets not containing polyenoic fatty acids, and this symptom is not prevented by 'Selenite'[6].

The differences in the etiology of exudative diathesis and encephalomalacia clearly call for further study. We have therefore studied the influence of two different polyenoic fatty acids, namely, linoleic and linolenic, on the two symptoms.

The composition of the vitamin E-free basal diet used is shown in Table 1. Analyses of the yeast and gelatine (petroleum ether extraction from acidified alkali-hydrolysate and subsequent alkali-isomerization) showed that the amount of polyenoic fatty acids in this diet was less than 0·016 per cent.

The ethyl esters of linoleic and linolenic acids were added daily at a level of 1·5 per cent to the basal diet. (In our Department it has been found that Fleischmann yeast, Type 50*B*, has a powerful antioxidant effect, so that poly-unsaturated fatty acids incor-

Table 1. Composition of Basal Diet (gm./100 gm.)

Fleischmann yeast, type 50*B*	40
Gelatine	3
Salt mixture (ref. 7)	5·17
Vitamin mixture (ref. 7)	0·10
Choline chloride	0·20
Sucrose	51·53

Plus 0·001 gm. dicalcium salt of 2-methyl-1,4-naphthohydroquinone diphosphoric acid ester ('Synkavit', Roche) per 100 gm. diet. Vitamins A and D_3 were given in aqueous solution (ref. 7), 0·1 ml. twice a week each animal, corresponding to 250 I.U. vitamin A and 20 I.U. vitamin D_3 a day.

porated in a diet of the composition mentioned are only slightly autoxidized when left on open trays for a period of 24 hr. at 26° C. This is contrary to what happens when casein is the source of protein in the diet. The ethyl esters of linoleic and linolenic acids were obtained from the Hormel Institute, Austin, Minn. The linolenate, which had been prepared via the hexabromide, contained some trans-fatty acids as shown by infra-red spectrophotometry.)

Chicks which had received a commercial chicken mash low in vitamin E during the first two weeks after hatching[7] and thereafter were reared on the experimental diets showed the symptoms listed in Table 2 within 28 days.

It is evident that exudative diathesis was produced by both the two polyenoic fatty acids examined, but encephalomalacia only occurred with linoleic acid.

About one-third of the chicks with exudates in the linoleate and linolenate groups had peroxides (values ranging from 3·8 to 49·3) in the affected fat tissue. No peroxides could be detected in the fat tissue of the chicks which had no exudates.

The fact that the incidence and severity of exudative diathesis was less in the linoleate group than in the linolenate group may be due to the fact that, in the linoleate group, 11 out of the 12 chicks died from encephalomalacia before the end of the experimental period. In the linolenate group, however, 9 out of 12 chicks lived through the entire experimental period.

The observation that linoleic acid produces encephalomalacia in the absence of vitamin E is in accordance with the results of earlier experiments in which peanut oil treated with 'Filtrol' was used as addition to an otherwise fat-free and vitamin E – free diet[8].

The present experiments suggest that a suitable diet for producing encephalomalacia may be one containing linoleic acid and a trace of 'Selenite' in order to prevent simultaneous occurrence of exudative diathesis.

Since dietary linoleic acid is, to a large extent, converted into tetraenoic (arachidonic) acid, it is possible that linoleate exerts its encephalomalacia producing effect via arachidonate. Earlier studies[2] have demonstrated that the fraction of hog liver fatty acids which remains in solution in acetone at −76° C. has a powerful effect in provoking encephalomalacia. This fraction is known to contain arachidonic acid. Addition of cholesterol to a diet producing encephalomalacia decreases the incidence of encephalomalacia and favours the development of exudative diathesis[1]. This may be related to the observation that, when added to a diet containing linoleic acid, cholesterol decreases the deposition of tetraenoic acid in the liver[9]. However, further studies are required to investigate more fully the part played by tetraenoic and other polyenoic fatty acids as well as their isomers in vitamin E-deficiency symptoms.

Table 2. Experimental Feeding Period: 28 Days

Addition to basal diet	No. of chicks in group		No. of chicks with exudative diathesis	No. of chicks with encephalomalacia
	at beginning of experiment	alive at end of experiment		
None	12	12	0	0
1·5 per cent ethyl linoleate	12	1	3*	11
1·5 per cent ethyl linolenate	12	9	7†	0

* None of the exudates were so severe that they affected the general behaviour of the chicks.

† Four of these chicks had very severe exudates.

The dietary level of linoleic acid used in the present experiments corresponds approximately to the amount of this acid in a diet containing 60 per cent torula yeast '3*N*' without added fat[6]. Nevertheless, such a torula yeast diet produces only a few cases of encephalomalacia and a very high incidence of exudative diathesis. This is suggestive of the occurrence in torula yeast of principles counteracting encephalomalacia and favouring exudative diathesis. The existence of factors provoking exudate, in addition to the particularly effective polyenoic fatty acids has already been proved, since we have found that silver acetate added at a level of 20 p.p.m. silver ions to the basal diets mentioned and certain other basal diets has a pro-exudative effect.

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Inability of Epinephrine to protect Rhode Island Chicks against the Lethal Action of X-Rays

Stearner *et al.* have observed that young White Leghorn chicks[1] are protected against radiation mortality by epinephrine in solution in oil. I have repeated these experiments with Rhode Island chicks, which are more radio-resistant than White Leghorns, reproducing Stearner's conditions so far as the number and time of injections and the amounts of epinephrine injected are concerned.

Twenty-one day old Rhode Island chicks were irradiated with 2,000-r. X-rays, administered at a dosage-rate of 100r./min. An oily solution of epinephrine (Parke Davis) was injected into the pectoral muscles 5 min. before and 5 min. after irradiation, 2·5 or 5 mgm./kgm. being injected each time.

I have also used epinephrine, ephedrine and privine (2-naphthyl-(1′)-methyl-imidazoline nitrate) in aqueous solution.

Table 1. EFFECT OF INTRAMUSCULAR INJECTIONS OF EPINEPHRINE IN PEANUT OIL ON INITIAL AND DELAYED MORTALITY OF X-IRRADIATED RHODE ISLAND CHICKS
(Total dose, 2,000 r., dosage-rate 100 r./min.)

Dose of epinephrine before and after X-rays (mgm./kgm.)	No. of animals	Total mortality at 30 days (per cent)	Initial mortality at 0–2 days (per cent)	Delayed mortality at 3–30 days (per cent)
Controls	25	84	64	20
2·5	20	85*	60*	25*
5	25	80*	72*	8*

* Variations not statistically significant

After 30 days, the mortality among the irradiated chicks treated with epinephrine in oil was the same as that of the control chicks irradiated with 2,000 r. (Table 1). Initial mortality (0–2 days) was higher in animals injected with 5 mgm. of epinephrine in oil per kgm. body-weight than in irradiated controls.

Although I used the same technique as Stearner and his collaborators for injecting epinephrine obtained from the same source, I have been unable to reproduce with Rhode Island chicks the results obtained by these workers with White Leghorns[2]. My techniques differed from theirs in that I used a higher dosage-rate of irradiation (100 r./min.) and a higher total dose, and in the age and the race of the chicks employed. However, in my experiments a total dose of 2,000 r. administered to my control chicks gave a mortality after 30 days approximately equal to that found by the American authors[1] after 15 days in White Leghorns irradiated with 1,000 r. Not only did I find that no protection was afforded by epinephrine dissolved in oil, but mortality was accelerated among irradiated chicks when 5 mgm./kgm. was administered before and after irradiation.

Some assays have shown that epinephrine and ephedrine in aqueous solution have no protective action[3]. Privine, which is also a vasoconstrictor in the case of mammals, is very toxic (apathy, paralysis, dyspnea) and totally ineffective in the case of X-ray sickness in chicks.

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Effect of Analogues of Glutathione on the Feeding Reaction of Hydra

LOOMIS[1] has shown that the 'feeding reaction' which *Hydra littoralis* exhibit after they have captured living prey is controlled chemically: the feeding reaction is elicited by glutathione released from the prey. In the absence of prey, glutathione induces writhing of the tentacles and, in higher concentrations, glutathione causes the hydra to retract the tentacles. These effects were found to be more marked when the hydra had previously been starved for several days. Loomis found that the effect was quite specific and that even the closely related aspartathione was inactive. Two analogues of glutathione (ophthalmic acid and norophthalmic acid) have recently been isolated from calf lens[2-4]; they differ structurally from glutathione in that the SH group is replaced by a CH_3 group in ophthalmic acid, and an H atom in norophthalmic acid. We have now found that these analogues of glutathione also elicit the feeding reactions in *Hydra littoralis*.

The experimental conditions were the same as those used by Loomis. The hydra were kept in a modified tap water medium[5], and were starved for five days before each experiment; during starvation the medium was renewed daily. The results are shown in Table 1; the activity is classified as strongly marked (++), clearly discernible (+), doubtful (±) or absent (0). Ophthalmic acid is seen to be more active, and norophthalmic acid less active, than glutathione, which itself is active at a concentration of only 10^{-5} *M*. Since the analogues do not contain an SH group, it follows that the SH group of glutathione is here unnecessary; thus for the first time a specific biological effect of glutathione is found to be unrelated to the SH group, but strongly dependent upon the molecular size and shape.

Table 1. ACTIVITIES OF GLUTATHIONE, OPHTHALMIC ACID AND NOROPHTHALMIC ACID IN ELICITING THE FEEDING REACTION OF *Hydra littoralis*

Concentration (*M*)	Activity*		
	Glutathione	Ophthalmic acid	Norophthalmic acid
10^{-3}	++	++	+
10^{-4}	+	++	±
10^{-5}	+	++	0
10^{-6}	0	+	
10^{-7}	0	0	

* See text for description of categories.

Two analogues of glutathione which do not occur naturally have also been tested; these are inactive themselves, but inhibit the elicitation of the feeding response by glutathione or ophthalmic acid. The results for the adduct obtained from glutathione and N-ethylmaleimide are shown in Table 2; the activities are classified as described above. The other synthetic inhibitor is the sulphonic acid, γ-L-glutamyl-L-sulphoalanylglycine, and this gave the same pattern of results. Furthermore, similar results were obtained when these synthetic inhibitors were tested against the feeding reaction elicited by ophthalmic acid; norophthalmic acid, itself less active, was more readily inhibited. Thus, of the analogues of glutathione, the two naturally occurring ones are active, but the two synthetic ones are inactive and inhibitory. In the glyoxalase reaction, however, where glutathione is a coenzyme and its SH group enters into the reaction, both the naturally occurring and synthetic analogues are inhibitors[6,7].

Ophthalmic acid was not detected in the *Artemia* on which the hydra fed, so that there is no evidence that the feeding reaction elicited by ophthalmic acid occurs under ordinary conditions.

We are greatly indebted to Dr. W. F. Loomis for supplying us with *Hydra littoralis*; we are also

Table 2. ACTIVITY OF GLUTATHIONE IN THE PRESENCE OF AN INHIBITOR (THE ADDUCT OF GLUTATHIONE AND N-ETHYLMALEIMIDE) IN ELICITING THE FEEDING REACTION OF *Hydra littoralis*

Concentration of inhibitor (*M*)	Concentration of glutathione (*M*)	Ratio of concentration of inhibitor to concentration of glutathione	Activity*
10^{-3}	10^{-3}	1	++
10^{-3}	10^{-4}	10	+
10^{-3}	10^{-5}	100	0
10^{-2}	10^{-2}	1	+
10^{-2}	10^{-3}	10	±
10^{-2}	10^{-4}	100	0

* See text for description of categories.

grateful to the Distillers' Company, Ltd., for a gift of glutathione, and to Miss Stewart for care of the hydra; one of us (E. E. C.) is in receipt of a Thornton bursary.

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Adrenal Activity in Subjects with Complete Transverse Lesions of the Spinal Cord

HUMAN subjects with complete transverse lesions of the upper thoracic and cervical spinal cords show some features of hypoactivity of the adrenal medulla and of the adrenal cortex: the concentration of adrenaline in the peripheral plasma[1] and the excretion of 17-ketogenic steroids in the urine[2] are both significantly lower than normal.

Since eosinophilia is commonly found in conditions of adrenal insufficiency it was of some interest to measure the number of eosinophils in the blood of patients with complete transverse lesions of the upper thoracic and cervical cord, that is above the fifth thoracic vertebra (T.5), and to compare them with the values found in patients with cord lesions below T.5. This latter group of patients showed no features of adrenal hypoactivity. Eosinophil counts were carried out by the method of Pilot[3].

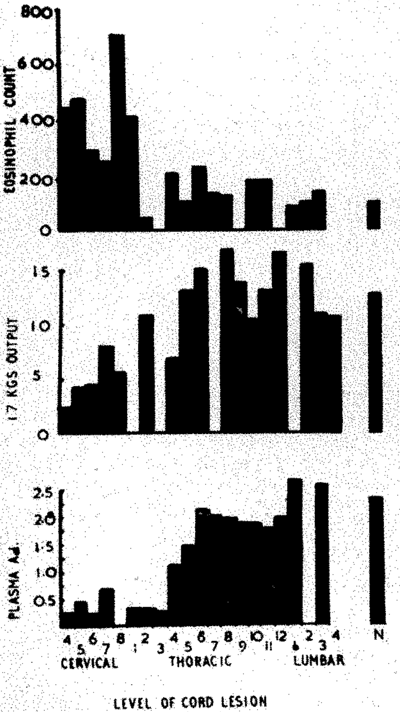

Fig. 1. Mean values of eosinophil count in cells per mm.^{3} (top), 17-ketogenic steroid excretion in mgm. per 24 hr. (middle), and plasma adrenaline in μgm./l. (bottom). The columns marked 'N' show the mean results of groups of normal control subjects

Thirteen out of twenty-one patients with complete spinal cord lesions above T.5 showed some degree of eosinophilia with counts above 300 per mm.^{3}; twenty-three patients with lesions complete below T.5 were all normal.

The accompanying figure shows the mean values for plasma adrenaline, 17-ketogenic steroid excretion and circulating eosinophils in patients with complete transverse lesions of the spinal cord at levels from the fourth cervical to the fourth lumbar vertebra.

Patients with high cord lesions tend to have high eosinophil counts, low values for the plasma adrenaline and low excretions of 17-ketogenic steroids; patients with lesions of the lower thoracic and lumbar cords show normal values.

Long[4] has developed the idea that adrenaline, which is assumed to be released during stress, stimulates the secretion of adrenocorticotrophic hormone. He found that the adrenal cholesterol and ascorbic acid fell under these circumstances and also after adrenaline infusion.

Our investigations were carried out on fit subjects with spinal cord lesions of long standing who were not under stress. It is interesting that the association between the activity of the adrenal cortex, as measured by the eosinophil count and the excretion of 17-ketogenic steroids, and the output of adrenaline still appears to hold even in circumstances of subnormal adrenaline output.

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Acetylcholine in Mammalian Neuromuscular Transmission

AFTER reviewing experimental results described in the literature, Acheson[1] came to the conclusion in 1948 that the amount of acetylcholine liberated by a single impulse at a presynaptic nerve terminal in muscle and sympathetic ganglia is probably of the order of $1 \cdot 5 \times 10^{-16}$ gm. (10^{-18} moles). He pointed out the large discrepancy between this quantity and the relatively large amounts (3×10^{-14} moles) hitherto found necessary for excitation when applied directly to the muscle. This discrepancy has been much reduced in recent years by the electrophoretic application of acetylcholine from micropipettes[2,7], and spikes have been produced in frog muscle fibres by this method with as little as $5 \cdot 5 \times 10^{-16}$ moles[7]. However, there still remained a substantial difference, and most of the potentials obtained by this method have not been strictly comparable with end-plate potentials elicited by nerve stimulation since they have a much slower time-course. For example, the quickest potential published by del Castillo and Katz[3] rose to its maximum in 13 msec. These authors concluded that much faster potentials, and even greater sensitivity to acetylcholine, would be expected in the case of nervous release of acetylcholine, where the diffusion distance is less than 1μ; in their

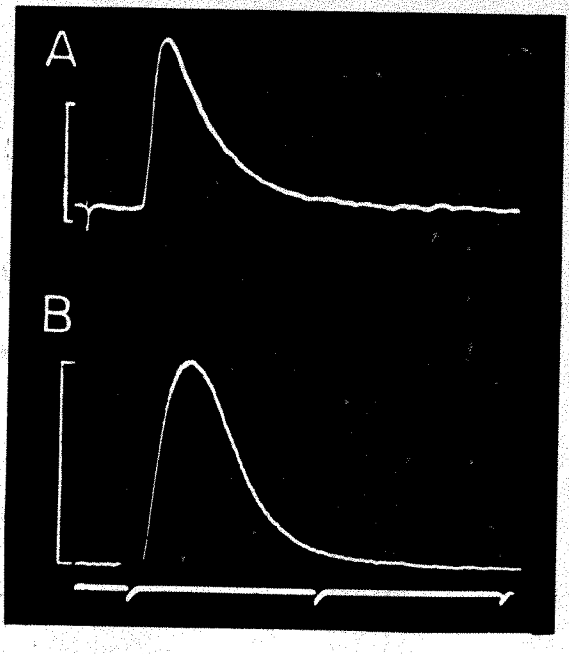

Fig. 1. *A*, End-plate potential evoked by stimulation of phrenic nerve at 2 c./s. The muscle was paralysed by 15·0 m*M* magnesium. *B*, Acetylcholine potential evoked in another muscle by a 1 msec. pulse of current ($3 \cdot 5 \times 10^{-8}$ amp.) at a rate of 1 c./s. In both cases, muscles were rat diaphragms, at 24–25° C.; the potentials were recorded with intracellular electrodes. Voltage scale: 5 mV. in *A* and 10 mV. in *B*. Common time scale: 10 msec.

experiments, the distance of the acetylcholine pipette from the end-plate was estimated to be 10–20μ (in a later paper[4], they mention potentials with a rise time of 2–5 msec.).

By the use of a similar technique, we have found that acetylcholine potentials could be produced in the rat diaphragm with amounts as small as $1 \cdot 5 \times 10^{-17}$ moles (assuming a transport number of 0·3 for ACh+). The experiments were performed *in vitro*, at room temperature (24–25° C.), with an intracellular recording electrode (filled with 3 *M* potassium chloride) in the end-plate region of a muscle fibre; jets of acetylcholine were delivered from an external micro-pipette filled with 2–4 *M* acetylcholine (as chloride, Roche Products) by square outward current pulses lasting 0·1 to 1·0 msec. The lowest values were obtained with 0·1 msec. pulses. No allowance was made for the appreciable loss of current to be expected with such short pulses in view of the relatively high pipette resistance and capacitance to earth.

The amplitude and time course of the fastest acetylcholine potentials were extraordinarily sensitive to the slightest disturbance. The fastest potentials had a time course comparable with that of end-plate potentials evoked by nerve stimulation. Fig. 1 shows on the same time scale the potential produced with a 1 msec. pulse of acetylcholine ($3 \cdot 5 \times 10^{-11}$ coulombs or 10^{-16} moles) and a typical end-plate potential in another diaphragm paralysed by 15·0 m*M* magnesium (the voltage scales differ by about 15 per cent). The rise time to the maximum of the acetylcholine potential is approximately twice as long as the corresponding time for the end-plate potential (1·3 msec.). A time lag of about 3 msec. is consistent with a diffusion distance of about 4μ. The peak of the acetylcholine potential is somewhat more rounded than that of the end-plate potential, but its rate of fall is fairly similar, so that the total durations of the two potentials differ by relatively little.

It seems that with the present technique an even closer approximation to nervous transmission is likely to be limited by the width of the end plate (19–28μ in the rat diaphragm[2]). The rounded peak of the acetylcholine potential might well be caused by saturation of the receptors closest to the pipette.

Although some discrepancy may therefore be expected to remain, the value computed somewhat indirectly by Acheson (10^{-18} moles) is quite likely to be too small by a factor of at least 10, as suggested by Acheson himself, since most experimental errors would tend to reduce it. As a further source of error, presynaptic failure of nerve conduction may well occur during repetitive stimulation[5]; it is particularly likely under conditions of reduced oxygen supply[6] such as would be expected during the perfusion of muscle with Locke solution as in the experiments reviewed by Acheson.

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Metabolism of Coumarin and Related Compounds in Cultures of *Penicillium* Species

STUDIES by Mead *et al.*[1] on the metabolic fate of coumarin and related compounds in rabbits showed that *o*-coumaric acid was partly converted to 4-hydroxycoumarin while coumarin was converted neither to *o*-coumaric acid nor to 4-hydroxycoumarin.

In this laboratory the biological oxidation of coumarin and related compounds has been studied using moulds isolated from soil, following the technique of Henderson and Farmer[2]. Two of the moulds isolated, *Penicillium jenseni* and *Penicillium nigricans*, are able to utilize coumarin as sole carbon source in a modified Czapek medium, although rate of growth is very slow. During growth the concentration of coumarin falls steadily, but at no time is it possible to isolate any other coumarin derivatives. In a similar medium containing sucrose and coumarin, growth is vigorous, and a little umbelliferone is detectable.

When the medium contains *o*-coumaric acid in place of coumarin as sole carbon source, again growth rate is slow, but as the concentration of *o*-coumaric acid falls it is possible by chloroform extraction to isolate from the medium relatively large amounts of 4-hydroxycoumarin. The presence of sucrose in the medium in addition to *o*-coumaric acid does not interfere with this hydroxylation.

The isolated 4-hydroxycoumarin has been identified by its R_F values using ethylene glycol systems[3], by its mobility on paper electrophoresis in 0·2 *M* borate at *p*H 8·5, and by its ultra-violet spectrum in cyclohexane.

Paper chromatography and electrophoresis of the chloroform-soluble matter in the medium also revealed a compound with R_F values, and mobilities identical with those of dicoumarol (3 : 3-methylene-bis-4-hydroxycoumarin), but so far in too small a quantity to allow of purification for spectrophotometric comparison with pure dicoumarol. Growth of either species of *Penicillium* in a medium containing 4-hydroxycoumarin and sucrose also provided evidence for the presence of dicoumarol. In every case uninoculated control solutions showed no traces of the conversions described above.

It appears that *o*-coumaric acid, and not coumarin, may be converted to dicoumarol in cultures of *Penicillium* species isolated from soil. This is significant in view of the investigations[4] which led to the identification of dicoumarol as the hæmorrhagic agent in spoiled sweet clover hay. An early report by Smith and Brink[5] stated that alfalfa hay, containing no coumarin derivatives, developed hæmorrhagic properties when mixed with coumarin and allowed to ferment, and it has been generally supposed that coumarin is the precursor of the dicoumarol formed in fermented sweet clover hay. However, Stahmann *et al.*[4] commented on the small fraction of the total coumarin present which was apparently converted to dicoumarol. *o*-Coumaric acid is present in much lower concentrations in general, and a substantial conversion of this substance to dicoumarol by contamination of the hay with soil fungi could lead to concentrations of dicoumarol of the order of those found.

Fuller details of this work will be published in due course.

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Abnormally Low Ultimate *p*H in Pig Muscle

The *p*H attained when the process of post-mortem glycolysis has ceased—the ultimate *p*H[1]—is influenced by the type of muscle considered, the species in which it occurs and the physiological condition of the animal from which it is derived. In the longissimus dorsi (l. dorsi) muscles of horses[2], oxen[3] and pigs[4], the glycogen reserves of which have not been depleted by such stresses as pre-slaughter exercise, starvation or excitement, an ultimate *p*H of about 5·5 is characteristic. At this *p*H the enzymes which effect glycolysis are assumed to be inactivated, and residual glycogen may be found. Stress, by depleting glycogen reserves at or before death, is therefore normally associated with values of ultimate *p*H above 5·5.

Some observations on pig muscles having an ultimate *p*H considerably lower than 5·5 are now briefly reported. Superficially these muscles are characterized by their loose texture, their exudative condition and, generally but not always, by the fact that they are almost white whereas normal pork is pink to light red in colour.

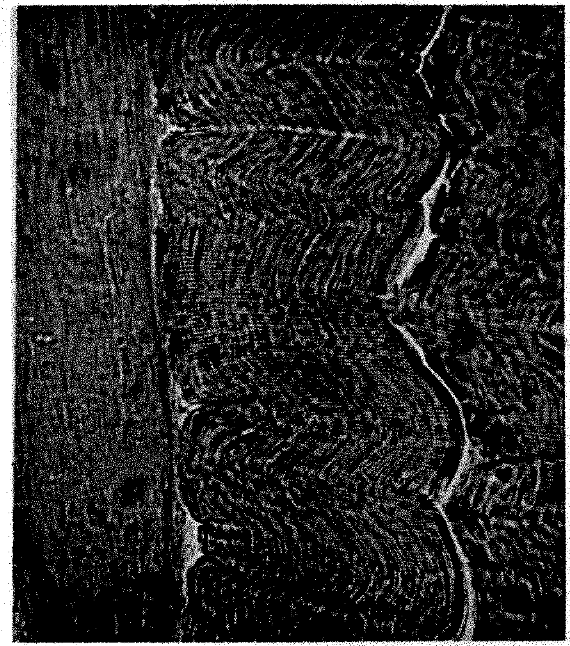

Fig. 1. Longitudinal section of pig semimembranosus muscle, *p*H 4·94. Note absence of cross-striations in left-hand fibre and twisting and corrugation of the other two. Fixed in formalin : celloidin embedded. Stained : hæmatoxylin, van Gieson. (× 200)

This 'white muscle' condition has aspects in common with "muskeldegeneration" in Danish[5] pigs and with "la myopathie exsudative dépigmentaire du porc" in France[6,7], but there are also features which appear to distinguish it from these and other distrophic disorders of muscle.

In the present work an ultimate *p*H of 5·1 or below was frequently found, the lowest value being 4·78 in l. dorsi. The latter and the semimembranosus appear to be particularly susceptible to the condition. Susceptibility also varies within a single muscle. White and pink locations in the semimembranosus only 1 cm. apart have had ultimate *p*H values of 4·94 and 5·56 respectively. In l. dorsi muscles having low *p*H there is a lower content of acid-soluble phosphorus (about 1·8 mgm./gm. compared with 2·0 mgm./gm. in l. dorsi of normal pigs) and a lower buffering power ($5{\cdot}66 \times 10^{-5}$ equivalent/*p*H/gm. compared with about $5{\cdot}9 \times 10^{-5}$ normally).

Histologically there are several unusual features, the degree of abnormality being related to the ultimate *p*H. For example, in muscles with an ultimate *p*H of 5·3, although cross-striations were still clear, the muscle fibres were frequently twisted and broken ; in those at *p*H 5·1 the protein gel in the interior of more than half of the fibres appeared to have coagulated. At *p*H 4·9 all fibres were abnormal : some of these showed no cross-striations but had manifest longitudinal markings ; others had still cross-striations but were both twisted and finely corrugated (Fig. 1). The general histological picture resembles that found in isolated muscle where *rigor mortis* has been precipitate due to an abnormally high rate of breakdown of adenosinetriphosphate (Bendall, J. R., personal communication). This aspect of the question is being studied further.

It is hoped to publish a fuller account of these investigations elsewhere.

The technical assistance of Messrs. W. A. Deer and N. King is gratefully acknowledged. Samples of

pig muscle were kindly provided by Messrs. Robert Lawson and Sons (Dyce) Ltd.

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Establishment of Permanent Cell Strains from Human Adult Peripheral Blood

CULTURES of cells from the buffy coat of the blood were described by Carrel and Ebeling in 1922[1], and since then they have been used by many workers. Several have described the appearance of fibrocytic cells in these cultures[2]. They have been reported as early as one day after explantation, and Hulliger[2], using mainly rabbit buffy coat, found that within one to three weeks cultures of fibrocytic cells were frequently formed in which a high level of mitosis occurred. It would be useful to be able to establish strains of cells from individuals whenever they are required for certain genetic studies, and since the peripheral blood is the easiest tissue to obtain aseptically from volunteers, the possibility that permanent strains might be developed from this source was investigated. Strains were established from four out of five bloods. The technique used is as follows.

15–20 ml. of blood are collected in sterile siliconed tubes and buffy coat cultures are prepared in 50 ml. conical flasks, essentially by the method described by Allgöwer[2]. After one week a fluid medium consisting of 20 per cent horse or calf serum in Eagle's medium[3] (with phenol red) is added to the plasma clot cultures. About this time the cultures enter a static phase in which they remain for a period which varies from a few days to many weeks. The only evidence of the presence of surviving cells is in some cases the progressive fall in the *p*H of the medium. This is observed daily, and when it falls to 7·0 the fluid phase is renewed. Quite suddenly rapidly growing colonies of cells appear. These can be trypsinized in the usual manner and established in continuous cultivation. They resemble other 'fibroblastic' strains in morphology and grow very well in 20 per cent calf serum in Eagle's medium. They can be cloned quite easily by the dilution technique[4]. The chromosomes have been identified as human by Prof. Pontecorvo and Mr. C. G. Elliott of the Genetics Department of this University.

The origin of these cells is by no means certain. The following suggestions have been made : (1) They represent transformed monocytes or lymphocytes ; (2) they are cells carried into the vein during venepuncture ; (3) they are tissue fibroblasts or other cells, not usually listed among the leucocytes, which exist in small numbers in the peripheral blood. In view of the regularity with which they can be obtained, I feel that the second explanation is unlikely. But since their origin is at present uncertain they are best described as normal adult human buffy coat cells. We have four strains, HERT 1, HERT 2, HERT 3 and HERT 4, isolated from four different individuals and maintained in continuous culture for periods varying from six months to a year, with a minimum of thirty serial passages.

If these are normal blood elements, no matter what their precise origin, it seems that Allgöwer's suggestion that they give rise to the fibroblasts of granulation tissue has some justification. Also it seems not unlikely that many of the 'fibroblastic' strains of cells isolated from a variety of tissues may, in fact, have their origin from these blood cells. Finally, in view of the readiness with which the colonies grow from individuals the danger of using unfiltered serum in culture media is obvious.

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Protoplasts of Group A Beta-hæmolytic Streptococci

THIS communication records the preparation from strains of group *A* streptococci of bodies which appear to conform to the rigid definition of 'protoplasts' recently offered by Brenner *et al.*[1]. They have been prepared by enzymic digestion of living cells.

There are two enzyme systems which attack isolated cell walls of group *A* streptococci : the *Streptomyces albus* mixture[2] and the enzyme produced during bacteriophage lysis of group *C* streptococci[3]. Both enzyme systems have been used successfully to prepare protoplasts, but the latter enzyme system is the more suitable since the streptomyces mixture contains an enzyme(s) which attacks the protoplast membrane.

Our general method has been to incubate the streptococcus (Lancefield group *A*, type 14 concentration 10^8 orgs./ml.) with the enzyme in 2 *M* sodium chloride or 2 *M* sucrose for 30 min. at 37° C. Little change in turbidity, as measured spectrophotometrically, occurs in this time and microscopical examination of air-dried stained smears of the suspension shows discrete spherical particles. Under dark-ground illumination they are indistinguishable from the original streptococcus (except possibly smaller). The suspension is centrifuged, the precipitate washed twice with 2 *M* salt solution and resuspended in a medium of suitable composition for further studies. The properties of these protoplasts, are as follows :

Osmotic sensitivity. Suspension of the protoplasts in distilled water or dilute (less than *M*) buffer brings about immediate lysis with the release of internal components of the organism. Under appropriate conditions highly viscous preparations possibly containing polymerized nucleoproteins can be prepared. Centrifugation of the lysed material at 20,000 r.p.m. for 15–30 min. gives a small pellet of insoluble opaque residue.

Immunochemistry. The protoplasts can be shown to be free of antigenic substances normally believed to occur in the cell wall. The precipitating *M* antigen and agglutinating *T* antigen, together with the group hapten, are absent when tested for by conventional typing methods. Antisera prepared against both whole and fractionated protoplasts have failed to show evidence of antibody to any of the known cell wall components.

Chemistry. Rhamnose has been shown to occur almost exclusively in the cell wall of the group *A* streptococcus. In the process of protoplast formation the rhamnose is liberated in a soluble form, which is still serologically active as group hapten. Washed protoplasts have been shown to contain less than 10 per cent of the rhamnose present in a similar sample of washed streptococci treated with inactivated enzyme. (This is a minimum figure since no account was taken of any lysis which must have occurred on washing.)

Interaction with bacteriophage. Intact cells readily adsorb appropriate bacteriophage whereas protoplasts of the same strain fail to do so.

Growth of protoplasts. Many attempts under varying conditions have been made to induce the protoplasts to grow or synthesize new cell wall material. No success has yet been attained.

Behaviour of isolated cell walls. Isolated cell walls do not appear to undergo complete dissolution when treated with partially purified enzyme preparations. Group hapten is liberated (in some cases quantitatively) but an insoluble residue remains. None of the components liberated by the partially purified enzyme appears to be dialysable.

These properties show that the enzyme treatment has removed the cell-wall components from the streptococci, and that the osmotically fragile structures produced can justifiably be called protoplasts. These protoplasts of hæmolytic streptococci are similar structures to those produced by the action of lysozyme on *B. megaterium*.

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Calcium Exchanges of Ehrlich Ascites Tumour Cells of Mice *in vitro*

In a previous communication we reported the observation that when the isotope calcium-45 was injected intraperitoneally into mice bearing Ehrlich ascites tumours, the specific activity of the calcium of the cells had already reached that of the fluid after the shortest interval allowed between injection of the isotope and sampling the tumour (4 min.).

Subsequent experiments have confirmed this result, and we are now studying calcium exchange *in vitro*. In a total of six experiments in which cells labelled with calcium-45 *in vivo* were incubated *in vitro* for 10 min. at 37° C. suspended in unlabelled ascitic fluid taken previously from the same mouse, no significant exchange was found to take place between the calcium-45 of cells and fluid. The same result was obtained in five experiments in which unlabelled cells were incubated with ascitic fluid containing calcium-45. Preliminary experiments in which cells were incubated in ascitic fluid at 37° C. for up to 80 min. in the presence of calcium-45 indicate that, even for this period, exchange is so slow as to be negligible.

These results suggest that calcium exchange, which *in vivo* seemed so rapid and complete as to be plausibly explicable in terms of diffusion alone, in fact must depend on the metabolic condition of the cell.

We are at present studying the exchange of calcium by cells suspended in a nutrient, balanced medium, in the hope of imitating and investigating further the process which occurs *in vivo*.

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Amœboid Motility of Fresh Ascites Tumour Cells

Using the fresh ascitic fluid of ascites tumours, and no other medium, I have studied the amœboid motility of living tumour cells. The Ehrlich ascites carcinoma and three strains of the ascites hepatoma, *AH* 130, *AH* 602 and *AH* 7974, which are transplantable ascites carcinomas of the rat established by Yoshida[1], were used. The method was as follows. A small amount of ascitic fluid was withdrawn at any time from the peritoneal cavity of host animals by means of a fine, sterile glass pipette. One drop of fresh undiluted ascitic fluid was immediately placed on the centre of a clean cover-slip, forming a globule about 5 mm. in diameter. The excess ascitic fluid was removed with the glass pipette to leave a thin flat covering of fluid. The cover-slip was then inverted over a depression slide having a depression 15 mm. in diameter and 0·5 mm. in depth, around the rim of which sufficient vaseline had been smeared to act as a seal. A slight pressure was applied to the cover-slip to seal it completely with the slide. The hanging-drop preparation was then ready for microscopic observation. The observations were carried out at 37° C. in a chamber equipped with an electric warmer.

As a rule, one hour after preparation, tumour cells of each strain became actively amœboid. In time, most of the Ehrlich ascites carcinoma cells showed amœboid movement, becoming roughly fusiform with pseudopods (Fig. 1). The ascites hepatoma is not a free-cell tumour in the strict sense of the word, as was pointed out by Yoshida[1], that is, the tumour cells, being epithelial in nature, make cell associations ('islands') suspended in the ascitic fluid, and individually isolated tumour cells are also present. In the ascites hepatoma, with the exception of *AH* 602, isolated tumour cells displayed amœboid movement, and individual tumour cells forming islands were also observed to move with pseudopods (Fig. 2). According-

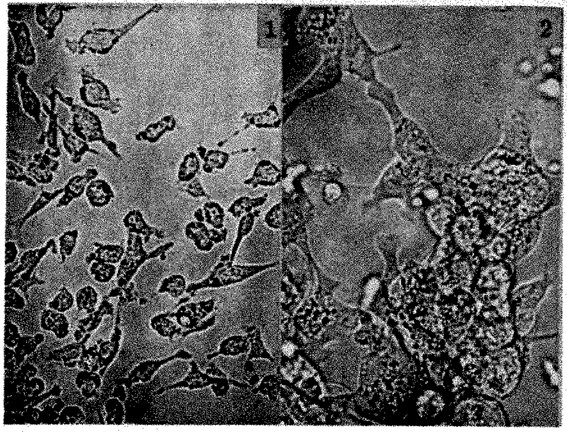

Fig. 1. Ehrlich ascites carcinoma, 6 hr. preparation. (× 135)
Fig. 2. Ascites hepatoma 130, 6 hr. after preparation. (× 270)

ing to my observations, tumour cells usually displayed amœboid movement actively for about six hours or more without showing any signs of degenerative cells. Intermingled with tumour cells, a few polymorphonuclear leucocytes, lymphocytes and macrophages were also seen. However, these could easily be distinguished from the tumour cells not only by their shape and size but even more accurately by the speed and character of their movement as reported by Enterline and Coman[2]. The alterations in positions of the estimated centre of the nucleolus of each tumour cell were traced on paper at five-minute intervals using Abbe's drawing camera. In this way, rates of amœboid movement were calculated in μ/min. (Table 1). Almost all tumour cells of *AH* 602 showed no movement with this recording technique. The average rate of movement of the Ehrlich ascites carcinoma and *AH* 7974 was 0·9 μ/min. and that of *AH* 130 was 1·0 μ/min. The difference of the average rates of movement of tumour cells among these three strains was not statistically significant. The maximum rate was calculated in μ/min. from the greatest distance any cell moved in a five-minute interval (Table 1). While tumour cells in *AH* 130 and *AH* 7974 almost always showed amœboid movement, cells in *AH* 602 did so very rarely. It is interesting that the motility should thus depend on the strain of hepatoma. Furthermore, it may be deduced that ascites tumour cells display amœboid movement in contact with the peritoneum *in vivo* too, and that they are most likely to invade in regions of the peritoneum where fluid stagnation can take place, that is, where tumour cells remain in contact with the peritoneum for some time, as Baillif[3] observed histologically, using mice inoculated with the Ehrlich ascites carcinoma.

I wish to express my sincere thanks to Prof. T. Yoshida for supplying the ascites hepatoma, and to Mr. Z. Aoki for his assistance during the course of this work.

Table 1. RATES OF AMŒBOID MOVEMENT OF EHRLICH ASCITES CARCINOMA CELLS AND ASCITES HEPATOMA CELLS

	No. of cells observed	Average rate (μ/min.) Mean ± S.E.	Maximum rate (μ/min.)
Ehrlich ascites carcinoma	19	0·9 ± 0·1	2·2
Ascites hepatoma 130	14	1·0 ± 0·1	2·2
Ascites hepatoma 7974	15	0·9 ± 0·1	2·8

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Cultivation of Isolated Embryonic Rat Tibiæ on a Chemically Defined Medium

THE successful culture of embryonic chick femora and tibiæ on a chemically defined medium has recently been described[1]. The medium used was No. 858[2], which was originally designed for the culture of Earle's L-strain cells. We have now been able to cultivate embryonic rat tibiæ on a closely related, chemically defined medium (J. D. Biggers and J. A. Lucy, unpublished work), thus paving the way for future studies on the specific nutritional requirements and metabolism of growing mammalian cartilage.

The bones have been cultured by means of the floating-lens paper technique devised by Chen[3]. Each watch-glass contained 0·5 ml. of medium and this was used for the cultivation of one tibia, the medium being renewed every second day. Rat fœtuses of a known age were obtained from the Medical Research Council strain of albino rats bred in the Department. The occurrence of mating was determined by finding a vaginal plug, the day on which the plug was found being counted as the first day of pregnancy. On the seventeenth day of pregnancy the uterus and conceptuses were excised. The fœtuses were immediately freed from their fœtal membranes and placed in fresh sterile Tyrode's solution at room temperature until the tibiæ could be isolated. In previous experiments it was found that the growth of the tibiæ was poor when the bones were isolated from fœtuses which had remained in the isolated uterus. The tibiæ were removed under a dissecting microscope and cleaned of as much extraneous tissue as possible, leaving the perichondrium intact.

Tibiæ from 17-day-old rat fœtuses may vary between approximately 1 and 3 mm. in length. This variation is mainly between pregnant rats, and may be accounted for largely in terms of the variation between individual rats in the number of embryos *in utero*. The shorter bones are composed of hyaline cartilage with intact hypertrophic cells in the centre of the diaphysis. The longer bones possess, in addition, a narrow collar of ossification in the diaphysis and, further, the central hypertrophic cells may have started to degenerate as a preliminary to endochondral ossification.

Pilot experiments showed that 17-day-old embryonic rat tibiæ elongate when they are cultivated on the chemically defined medium. Since previous work with embryonic chick long bones demonstrated that the degree to which bones elongate depends considerably on the level of glucose which is originally present in the medium[1,4] an experiment was designed to examine the effect of glucose on the elongation of rat tibiæ. Six batches of media were prepared, containing 0·5, 1, 2, 4, 8 and 16 mgm./ml. glucose respectively. These glucose levels form a set of six treatments which

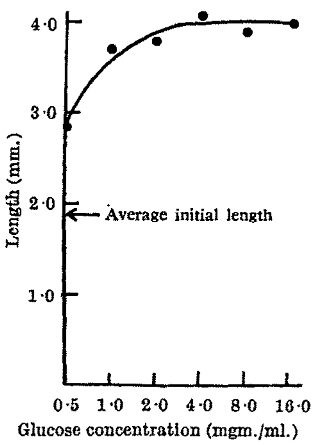

Fig. 1. The effect of glucose concentration on the length of 17-day-old embryonic rat tibiæ cultivated for five days on a chemically defined medium. Each point is the mean of six observations

were replicated six times in a randomized block design. Three pregnant rats were used, each providing the tibiæ for two blocks, and the tibiæ forming each block were allocated to the six treatments by means of a table of random numbers. Thus the comparison of the glucose levels is made within pregnant rats with a considerable gain in precision. The bones were drawn daily by means of a camera lucida, and the lengths of the bones at different stages were calculated from these drawings. Standard statistical methods were used to analyse this experiment. The results were transformed to the logarithmic scale before analysis.

The effect of concentration of glucose on the length of the bones after 5 days cultivation is shown in Fig. 1. The dose-response line was calculated after allowing for variations in initial length by an analysis of covariance. The results show that a glucose-level of less than 3 mgm./ml. is insufficient to promote maximum elongation. With higher glucose-levels the dose-response line becomes horizontal, indicating that glucose has no deleterious effects in concentrations up to 16 mgm./ml. This finding suggests that, as in the case of embryonic chick tibiæ, glucose penetrates the cells so quickly that the osmotic action of high concentrations is transitory, with no permanent effects on the subsequent growth of the bones. The elongation observed when the concentration of glucose in the medium is greater than 3 mgm./ml. was 112 per cent. Fig. 2 shows the type of growth which is obtained under these conditions. In some specimens the morphology remains approximately normal, and in others, curvature of the diaphysis may develop.

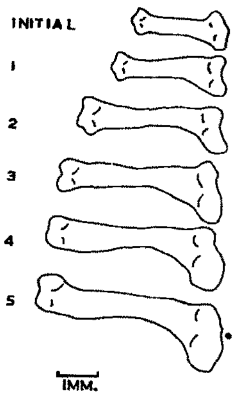

Fig. 2. Daily camera lucida drawings of a 17-day-old embryonic rat tibia cultivated on chemically defined medium (glucose concentration, 4 mgm./ml.). The medium was renewed on the second and fourth days

A second experiment was carried out to examine the histology of embryonic rat tibiæ grown on a chemically defined medium, containing 4 mgm./ml. glucose. Twenty tibiæ were explanted and at daily intervals four of these were chosen at random and fixed in Zenker containing 3 per cent acetic acid. Sections of these bones were stained with Ehrlich's hæmatoxylin and erythrosin and also with Heidenhain's hæmatoxylin. The bones remained healthy up to 4 days. The cells of the epiphysis and diaphysis retained their normal morphology, and the nuclei of these cells often contained two or three clearly defined nucleoli. Mitoses were easily found in the cells of the epiphysis up to the third day. At five days some of the hypertrophic cells of the diaphysis were degenerate, although the epiphyseal cells were still normal.

We have also attempted to culture 18-day embryonic mouse tibiæ on a chemically defined medium. The elongation which was obtained was of a similar magnitude to that recorded by Fell and Mellanby[5] using a natural medium. The elongation, however, was relatively small in comparison with that obtained with 17-day rat tibiæ. The difference in growth in the two cases is probably related to the difference in the initial structure in the tibiæ when they are explanted. In the rat, very little or no ossification of the diaphysis has occurred, and elongation is caused by hypertrophy of the diaphyseal cells, proliferation of the epiphyseal cells and secretion of new matrix. At this stage hypertrophy of the diaphyseal cells plays a major role in the elongation of the tibiæ which occurs *in vivo*[6]. In the mouse, on the other hand, there is considerable ossification of the diaphysis so that elongation cannot result from hypertrophy of diaphyseal cells, but largely depends on the proliferation of epiphyseal cells and the secretion of matrix between them. It would be interesting to explant mouse tibiæ at a stage of development comparable with that of 17-day-old embryonic rat tibiæ but, unfortunately, this has not been possible for technical reasons.

We wish to thank Mr. John Roberts for skilled technical assistance. Also we wish to acknowledge generous grants from the Royal Society, the Nuffield Foundation, the Medical Research Council and the Central Research Fund of the University of London, which made this work possible.

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Pigments Present in Arms and Pinnules of the Crinoid, *Antedon bifida* (Pennant)

In *A. bifida* red pigment usually occurs in protein granules in superficial connective tissue and in the eggs. The skeleton is colourless. When freshly detached pinnules are placed on slides and covered with sodium hydrosulphite solution, microscopic examination reveals that the red colour is immediately lost, but is restored in the granules when this solution is replaced quickly by sea water, and more markedly if drops of hydrogen peroxide are added to the sea water. Cannan[1] applied this test to *Arbacia* and *Echinus* echinochrome with similar results. The pigment restored in colour passes gradually into the protein pyriform bodies in the sacculi in *Antedon*. In distilled water the red pigment also passes into these bodies, which are discharged. Ball[2] used acid alcohol to extract echinochrome from *Arbacia*, and this solvent proved to be effective in removing selectively the red pigment from *Antedon* from Plymouth. Extraction procedure and tests performed were as follows:

1. Living arms and pinnules of 10 animals were cut up into 50 ml. of acid alcohol (70 per cent methyl alcohol containing 0·75 per cent conc. hydrochloric acid). Pigment extracted was placed in a separating funnel.
2. 50 ml. of petroleum ether and later 60 ml. of distilled water were added to the extract, which was shaken so that carotenoids and lipids might pass into the epiphase.
3. The hypophase containing the red pigment was run into a further separating funnel. About 20 ml. of distilled water of *p*H 5 (from a metal still) and 50 ml. of diethyl ether were added. The red pigment passed into the epiphase. If 20 ml. of glass distilled water is used instead, the red pigment remains in the hypophase, but on addition of a little hydrochloric or acetic acid it rises into the ether. In this instability the pigment resembles the hydroxy-naphthaquinone extracted by Ball and Cooper[3] from *Arbacia*, and by Millott[4,5] from *Diadema antillarum*; furthermore it is orange in aqueous acid solution and deep red in alkaline. A green colour, indicative of a phenol, appears if ferric chloride solution is added to a sample of this pigment in distilled water acidified with hydrochloric acid.
4. Samples of the ethereal solution of pigment dried with anhydrous sodium sulphate were examined in a Beckman spectrophotometer.

Absorption peaks occur at 262 mμ, 337 mμ, 460 mμ and there is an inflexion at 510 mμ—all as in the naphthaquinone pigment from *Diadema*[4,5] except that the maxima at 337 and 460 mμ are less well marked.

Yellow-brown lipid granules (which take up sudan dyes) are present in deposits in connective tissue and in coelomocytes. The brown colour is not removed by changes of acetone or ethylene chlorohydrin. In sections these granules blacken with alkaline silver methenamine. Since 0·13 per cent *l*-tyrosine is blackened slowly by ground arms and pinnules, some tyrosinase is possibly present in them, but use of the Hueck and Long Ziehl–Neelsen tests (see Pearse[6]) indicate that the yellow-brown material contains lipofuscin (oxidized lipid), not melanin, and bleaching tests bear this out, for very little brown colour is removed when sections 7μ thick are placed in 30 vol. hydrogen peroxide or 1 per cent bromine water for 48 hr.

Carotenoid pigments are present in gut wall and gonad, but can be extracted from the region of the arm-tip, which contains practically no gonad. I am indebted to Dr. L. R. Fisher for identification (using the methods of Fisher, Kon and Thompson[7]) of β-carotene, esterified astaxanthin (peak at 465 mμ in *n*-hexane), astaxanthin and xanthophyll (peak at 445–447 mμ in *n*-hexane) in extracts of arms and pinnules of *A. bifida*. Echinenone and vitamin A appeared to be absent. In its arms *A. bifida* seems to have several carotenoid pigments which resemble those found in the integument of starfish such as *Marthasterias glacialis*[8]. The carotenoids, α-carotene, β-carotene, echinenone, esterified astaxanthin and xanthophyll have been found in echinoderms and the occurrence of some of these pigments in the crinoid *A. bifida* might be expected.

Certain pigments present may be of dietary origin. *A. bifida* is both a detritus and suspension feeder. Small copepods are ingested with detritus. Diatoms are digested.

Like the echinoid *Diadema*[9], this crinoid responds to light. Animals so placed that aboral cirri rest on the bottoms of bowls will stay still in very dim light for half an hour, but rise up and swim when exposed to 160 ft. candles of light from an electric bulb for 4 sec. Preliminary work indicates that this response is also given when green, but not when blue, yellow or red filters are placed in front of the light; a light-sensitive pigment may be present in the nervous system.

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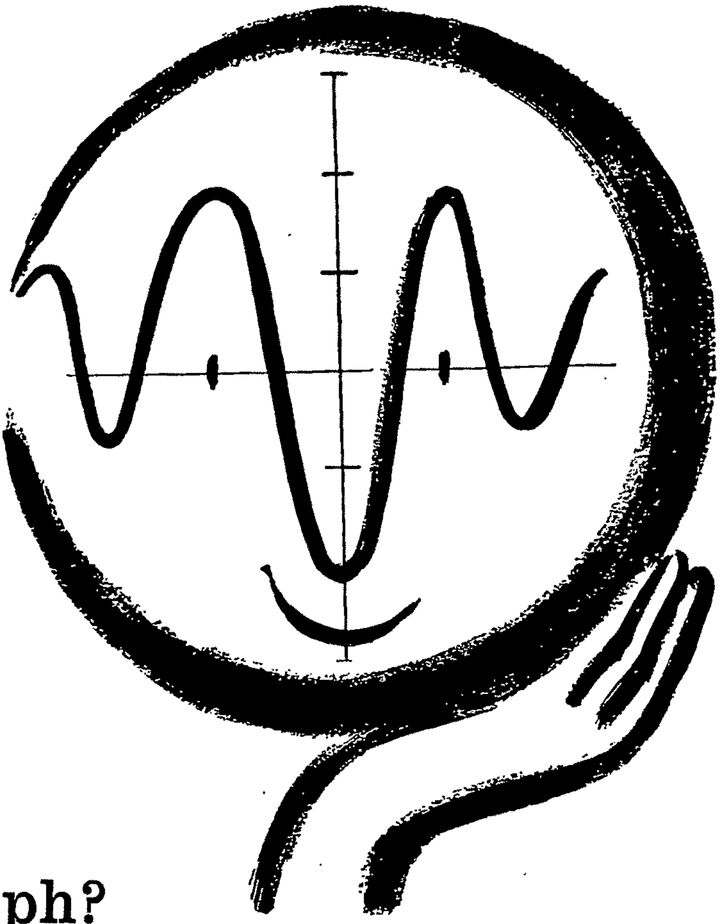
The Finer Structure of the Galeal Lamella in Adult Mosquitoes

The maxilla of the adult mosquito is a reduced structure in that the cardo and lacinia are almost lost, and the stipes is embedded below the alimentary canal. The functional maxilla is a lancet-like galea consisting of a chitinized rod with a trough-shaped membranous lamella on its outer edge. This lamella has been described in *Anopheles maculipennis* as possessing fine anastomosing striations and bearing at its distal extremity small, backwardly pointing teeth[1]. The piercing action of the maxillary galea has been described elsewhere[2].

Studies being carried out upon the detailed structure of the trophi of adult Culicidae have revealed that in many species the lamella has a more complex structure than previously believed. In *Aedes argenteoventralis*, *Culex horridus*, *C. cinereus* and *C. fatigans*, a very fine non-striated lamella on the inner side of the galea has been observed. The structure of the outer lamella has particularly been studied in *Aedes aegypti*, *A. grahami*, *Culex nebulosus*, *C. cinerellus*, *C. fatigans*, *Uranotaenia bilineata* and *Hodgesia*



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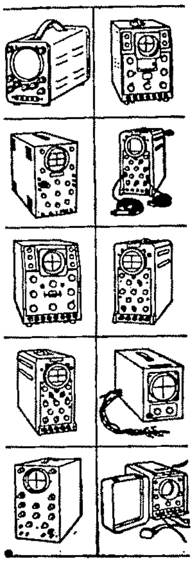

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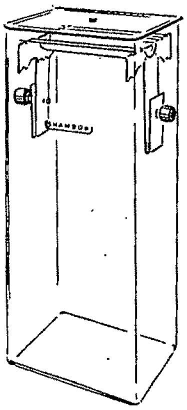

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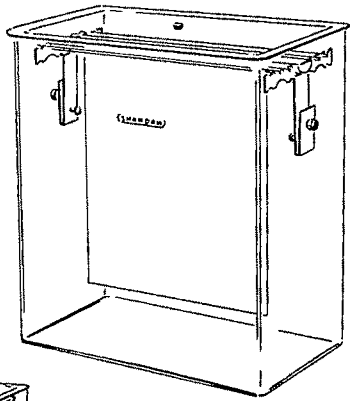

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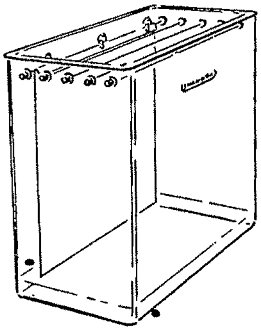

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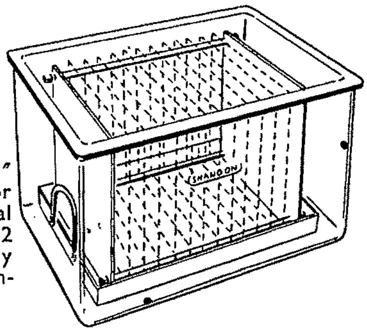

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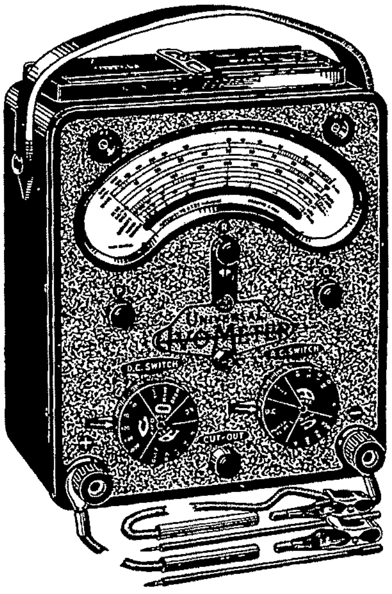

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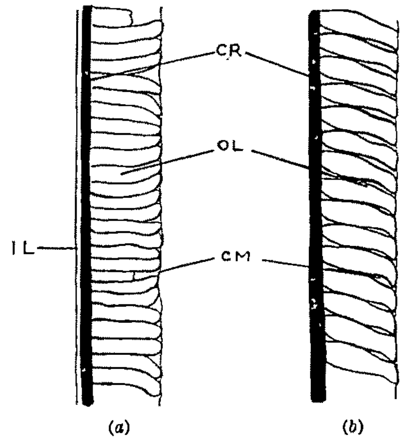

Fig. 1. Sections of the maxillary galeæ in (*a*) *Culex fatigans* and (*b*) *Aedes grahami*. *OL*, Outer lamella; *IL*, Inner lamella; *CR*, chitinized rod; *CM*, connecting membrane

nigeriae. In these species the lamella has the appearance of being composed of a great number of finger-like projections arising from the chitinized rod, which are separate at their distal extremities (Fig. 1). Normal pressure on a coverslip over the portion of the lamella under observation does not cause separtion of the individual parts, but when the lamella is broken these can be observed. Although these projections are considered to be separate entities, it has been observed that they are connected to one another by a much finer continuous membrane. Examination of longitudinal sections of the proboscis reveals that these projections are indeed separable when the galea is cut at an oblique angle while still in the labial sheath.

The structure of the lamella as described here has been observed in a number of widely separate species, and it is doubtful whether this type of structure is related to a particular feeding habit. Nevertheless, the possession of a lamella with a serrated, or semi-serrated, edge would be of value to a species which is a blood feeder and must therefore be able to pierce animal tissue.

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Dependence of Mitochondrial Swelling on Oxidizable Substrates

That the swelling of isolated mitochondria induced by various agents fails to occur under anaerobic conditions[1,2] suggested to us that swelling may be dependent on respiration. The probability of this is increased by the finding[3,4] that malonate prevents the swelling induced by succinate of mitochondria suspended in mannitol or sucrose solutions. We have therefore studied the effects of addition of substrates and inhibitors of oxidative metabolism on the swelling of mitochondria under various conditions. Mitochondria from livers of male rats (180–280 gm. body-weight) were prepared, suspended and stored in 0·44 *M* sucrose at 0° C. 0·05 ml. of mitochondrial suspension (25 mgm.-equivalents; 0·1 mgm. nitrogen) was added to 2·95 ml. of medium containing 2-amino-2-hydroxymethylpropane-1 : 3-diol (*tris*) chloride buffer, *p*H 7·5, and sucrose (final concentrations 25 m*M* and 0·3 *M* respectively). The optical density at 520 mμ (D_{520}) was recorded for periods up to 1 hr., the temperature being thermostatically controlled at 20°. Decreases in D_{520} were taken as a measure of swelling. Substrates were used in 1 m*M* concentration.

In contrast to the experience of previous workers[2,4], negligible swelling occurred during 1 hr. incubation in standard medium containing no further additions, even at 25° C. or after storage of the mitochondria at 0° C. for 26 hr.

With fresh mitochondria, the swelling caused by phosphate (10 m*M*) was increased in extent by addition of D-β-hydroxybutyrate, succinate, L-glutamate, L-malate or L-proline. These substrates, in absence of phosphate, produced negligible swelling. The effect of phosphate alone decreased as the age of the mitochondria increased. It was negligible after 18 hr., and was then restored by addition of the above substrates, which again had no effect when added alone. Pyruvate and α-oxoglutarate were, however, ineffective under these conditions.

The swelling of day-old mitochondria in the presence of succinate and phosphate ('succinate – phosphate swelling') was inhibited by malonate (1 m*M*) (Fig. 1), whereas the D-β-hydroxybutyrate – phosphate and L-glutamate – phosphate swelling was not. 1·8 m*M* amytal (5-ethyl-5-*iso*amylbarbiturate) prevents the oxidation by mitochondria of substrates

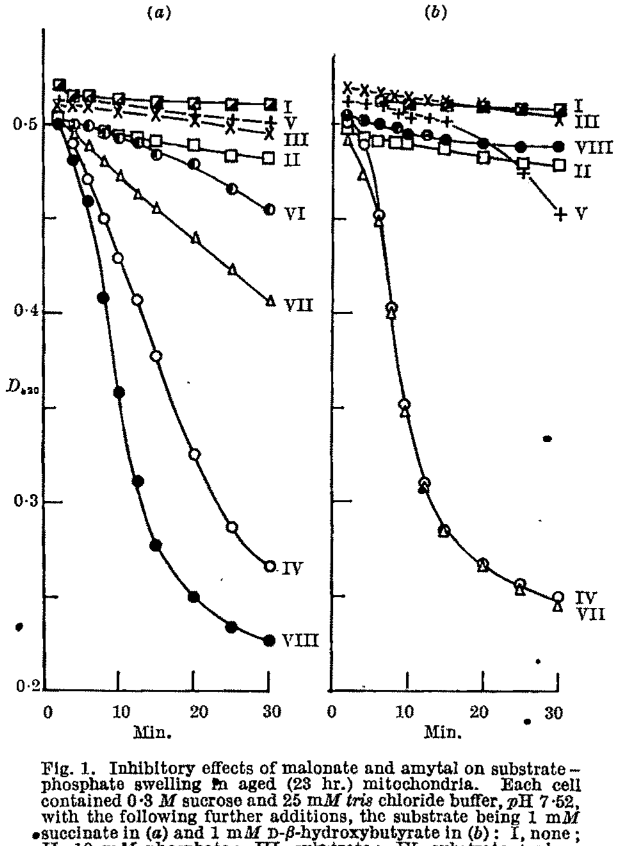

Fig. 1. Inhibitory effects of malonate and amytal on substrate – phosphate swelling in aged (23 hr.) mitochondria. Each cell contained 0·3 *M* sucrose and 25 m*M* *tris* chloride buffer, *p*H 7·52, with the following further additions, the substrate being 1 m*M* succinate in (*a*) and 1 m*M* D-*β*-hydroxybutyrate in (*b*): I, none; II, 10 m*M* phosphate; III, substrate; IV, substrate + phosphate; V, substrate + 1 m*M* malonate; VI, substrate (succinate only) + 2 m*M* amytal; VII, substrate + phosphate + malonate; VIII, substrate + phosphate + amytal

with diphosphopyridine nucleotide-linked dehydrogenases, but has no effect on the oxidation of succinate[5]. It is therefore of interest that 1·8 or 2 m*M* amytal inhibited the swelling caused by D-β-hydroxybutyrate, L-glutamate, L-malate or L-proline when added together with phosphate, but not the succinate – phosphate swelling (Fig. 1). Antimycin *A* (0·05 μgm./ml.), which blocks the respiratory chain[6], inhibited by 50–100 per cent the swelling induced by all the above substrates, including succinate, in presence of phosphate. Cyanide (1 m*M*) abolished the D-β-hydroxybutyrate – phosphate swelling of fresh and aged mitochondria.

Studies of the swelling induced by thyroxine have provided similar evidence that swelling may be dependent on the presence of oxidizable substrates. Thus, with fresh mitochondria, D-β-hydroxybutyrate enhanced, and with aged mitochondria restored, the thyroxine effect. D-β-Hydroxybutyrate – thyroxine swelling was inhibited by amytal and antimycin *A*. Still further evidence has been provided by the observation that with day-old particles in 0·2 *M* sucrose buffered with 25 m*M* *tris*, swelling was induced by succinate, D-β-hydroxybutyrate and L-glutamate. Malonate strongly inhibited the effect of succinate but accelerated that of the other two substrates.

With fresh mitochondria, replacing the *tris* buffer by glyoxaline or raising the sucrose concentration from 0·3 *M* to 0·5 *M* prevented swelling due to phosphate. This could then be restored by addition of D-β-hydroxybutyrate but not of L-glutamate, L-proline or succinate. With 0·45 *M* sucrose, however, L-proline and succinate were effective. In this connexion the recent finding[7] that high concentrations of sucrose inhibit the oxidation of different substrates in different degrees may be significant.

To summarize, under various conditions addition of certain oxidizable substrates promotes swelling. The effect of these substrates is diminished by substances known to inhibit their oxidation. We therefore suggest that in certain circumstances the swelling of mitochondria is dependent on their respiration. Since cyanide, amytal and high concentrations of sucrose inhibit the swelling of fresh mitochondria in the presence of phosphate or thyroxine, it may be that such swelling is supported by the oxidation of intrinsic substrates. Ageing might deplete the particles of substrates, and swelling then only occur if these are supplied. The stabilizing action of 2 : 4-dinitrophenol[4], which we have observed under many conditions, indicates that any effect of respiration on swelling may be exerted through coupled phosphorylation.

We thank Mr. Colin Taylor for his technical assistance.

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Effect of Low Temperature on the Vertical Distribution of Two Wood-boring Crustaceans

WHEREAS normal marine animals may be subjected to a temperature of not less than the freezing point of sea water, animals inhabiting the inter-tidal zone sometimes experience a much lower temperature. This is particularly so in the high-latitude shores of Norway where, during the winter, an inter-tidal zone of 3·5 m. is exposed twice daily to as low a temperature as −20° C. for 6 hr. or more. While studying the distribution of marine wood-borers in the Norwegian coasts, the possible stress of low temperature on these organisms came under consideration. Kanwisher[1] found some inter-tidal animals able to survive with as much as 75 per cent of their body fluids converted as ice. In *Limnoria*, Sømme[2] found that 83 per cent died when frozen in ice for 2·5 hr. With the view of finding out the extent of tolerance and any evidence of an adaptability to sudden drops in temperature which these animals experience when they are exposed to the air by the receding tide, the following experiments were performed.

Sectors approximately 50 cm. × 15 cm. × 5 cm. in size infected by borers obtained from nearby piles, were used in the experiments. These were acclimatized in a submerged condition from +6° C., the temperature of the surrounding water, to +2° C. during the course of 24 hr., after which they were exposed to air of different low temperatures in thermostatically controlled chambers where the variation during the course of any experiment was not more than ±2° C. After definite intervals of time, approximately 25 cm.^{2} of the superficial part of a block, with its contained animals, was sawn out and transferred to sea water at +2° C. where it was left for 12 hr. for recovery from exposure. After this treatment, the piece of wood was carefully dissected and the animals in it released into fresh sea water and watched for signs of life under a binocular microscope. Those that showed no signs of movement even after gentle teasing were counted as dead. Several series were run, each involving more than 500 animals, in order to allow for individual variation.

In these experiments an effort has been made to reproduce so far as possible the actual conditions experienced by these animals in Nature, thereby avoiding the artificial conditions of earlier observations (ref. 2, p. 153 and ref. 3) where animals were removed from their burrows, kept in water and subjected to low temperatures. However, the present procedure introduces an uncertainty regarding the actual temperature experienced by the animal in the burrow. Therefore, to give an idea of the rate of cooling of the log, a test run at −6° C. was carried out which showed that, at a depth of 2 cm., which is approximately the level to which *Limnoria* penetrates, the ambient temperature was reached within 3 hr. The results of the experiments are shown graphically in Fig. 1.

The three experimental periods presented in the graph represent three different exposure-periods to which *Limnoria lignorum* (Rathke) and *Chelura terebrans* (Philippi), occupying different positions on a pile in the inter-tidal zone, experience during the recession of the tide. Assuming 50 per cent mortality as a limit of tolerance of the population under consideration, it will be seen that a temperature of −4° C. is of no serious effect on *Limnoria*. On the

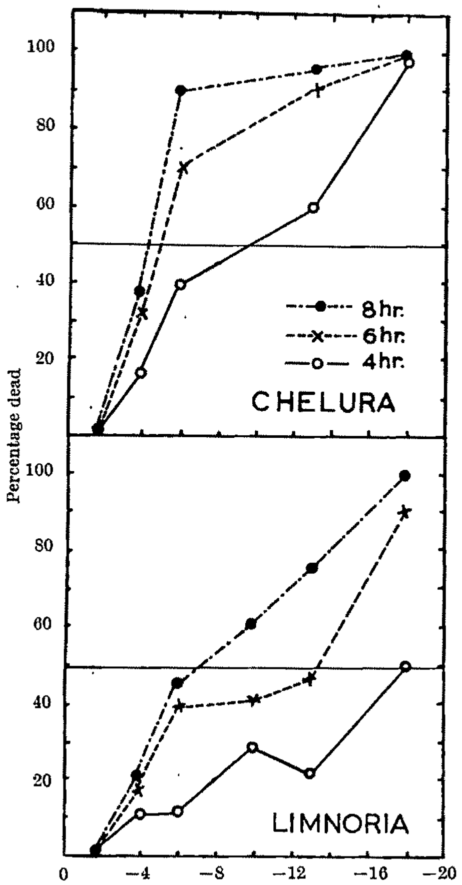

Fig. 1. Curves illustrating the death of *Chelura* and *Limnoria*, in sectors of logs exposed to different temperatures for various exposure times

other hand, this limit is almost reached within 8 hr. for the amphipod borer. This means that only those inhabiting the higher levels above mid-water mark will be affected by this temperature. Exposure to −8° C. for a period of 8 hr. kills 50 per cent of *Limnoria*, whereas this point is nearly reached within 4 hr. for *Chelura*. The latter temperature would therefore be a serious stress on those *Chelura* living both above and below the mid-water level. For a majority of *Limnoria* living at higher levels above the low-water mark a temperature of −18° C. is detrimental, since an exposure of only 4 hr. is sufficient to kill 50 per cent.

It may be inferred, therefore, that a sudden drop of temperature to −20° C. is lethal for those animals living high up on the piles above the low-water mark. Furthermore, the whole population of the inter-tidal belt experiences the great stress of low temperature during the period of exposure. It is doubtful that an organism which is subjected to such a stress under the conditions stated will continue to live and reproduce in an environment with this stress imposed rhythmically twice a day. The only escape to better conditions is by active migration to more favourable locations. It was interesting to note during the experiments that many of these animals when thawed out from a state of suspended animation showed a tendency to swim out of their burrows, suggesting that they are capable of migration. Evidently, as they emerge from their dark burrows they are influenced by photic stimuli. Since the degree of settlement has been reported as inversely proportional to increasing intensity of light[4], they move to lower levels in the same pile or adjacent piles. This would explain why empty burrows are found on piles above the low-water level after the winter months. It is noteworthy that during February, which is normally the coldest month in these localities, a secondary migration of *Limnoria* has been recorded (ref. 2, p. 202) besides the primary one, which takes place during September–October. It is not improbable that some of these February migrants are from the inter-tidal zone and have deserted it in search of a more favourable habitat.

This, then, may also explain the reported peculiarity in the vertical distribution of these borers in northern latitudes, where sub-zero atmospheric temperature is quite a normal feature during the greater part of winter. Those individuals that ascend too high up the pile would be killed, establishing an upper limit in the distribution. This limit may later be extended as re-colonization is made possible on the return of more favourable conditions and when population pressure drives individuals to unoccupied regions on the pile. The progressive decrease in the infestation of *Limnoria* from the mud-line upwards in these localities, in contrast to the condition reported from several places in the south (ref. 2, p. 151), support this view.

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Trisaccharides of *Lolium* and *Festuca*

In the course of an investigation into the distribution of water-soluble carbohydrates in seeds of the Gramineae[1], it was observed that two species of grass (*Lolium perenne* L. and *Festuca pratensis* Huds.) contained in their caryopses substantial amounts of a trisaccharide which was not detected in any of the thirty other wild grasses and cereals examined. This non-reducing trisaccharide (Fig. 1, X) had a specific rotation of +90·5° (without recrystallization), yielded equal amounts of galactose, glucose and fructose on acid hydrolysis and was readily broken down to fructose and a reducing disaccharide in the presence of invertase or very dilute acid. This ease of hydrolysis suggests that the trisaccharide resembles raffinose in containing a terminal β-fructofuranoside residue. Iodine oxidation[2] indicated that the galactose residue was at the non-reducing end of the disaccharide, and electrophoretic mobility of the disaccharide in borate was intermediate between the mobilities of laminaribiose and melibiose. Movement in borate is allied to the mode of linkage of sugar residues[3], disaccharides containing 1,2 or 1,4 linkages being of much lower mobility than those containing 1,3 or 1,6 linkages. The disaccharide under consideration would therefore appear to contain either a 1,3 or a 1,6 linkage. Although the electrophoretic behaviour in borate does not distinguish between α and β linkages, the high positive rotation of the trisaccharide suggests

Table 1. OLIGOSACCHARIDES OF *Lolium* AND *Festuca*

	Sucrose	Raffinose	Other trisaccharide	Tetrasaccharide
Lolium perenne	+	–	+	–
L. italicum	+	–	+	–
L. temulentum	+	–	+	–
Festuca pratensis	+	–	+	–
F. arundinacea	+	–	+	–
F. rubra	+	+	+	+
F. ovina				
Ssp. *ovina*	+	+	+	+
Ssp. *tenuifolia*	+	+	+	+

+, Present; –, not detected.

that the galactose and glucose residues are α-linked, and, since 6-glucose-α-galactoside is melibiose, it seems probable that the newly isolated disaccharide is 3-glucose-α-galactoside. The trisaccharide from *Lolium perenne* and *Festuca pratensis* is therefore tentatively described as α-D-galactopyranosyl-3-α-D-glucopyranosyl-2-β-D-fructofuranoside.

The presence of this rather unusual trisaccharide in two members of the Festuceae and its apparent absence from certain other members of the tribe (*Dactylis* and *Cynosurus*)[1] raises the interesting possibility of examining the biochemical affinities of different species of *Festuca* and *Lolium*. It will be recalled that recent morphological and genetical studies of these two genera have cast doubts on their traditional taxonomic alignment. Tutin[4], for example, concludes that *L. perenne* should be transferred to *Festuca*, while Stebbins[5], considering that *F. pratensis* is more closely related to *L. perenne* than it is to other species of *Festuca* such as the type species, *F. ovina*, regards the 'genus' *Lolium* as a section of the large and diverse genus *Festuca*.

The results of chromatographic analyses of the sugars of several species of *Lolium* and *Festuca* are shown in Table 1 and in Fig. 1. All species examined contained the trisaccharide described above, and all three species of *Lolium* gave chromatograms identical with those of *F. pratensis* and *F. arundinacea*. *F. rubra* and *F. ovina*, however, contained two other non-reducing oligosaccharides, both of which yielded galactose, glucose and fructose on hydrolysis. The more mobile of the two was chromatographically identical with raffinose; the other, which was probably a tetrasaccharide, was not chromatographically referable to stachyose, and calculation of the expression[6] log $[R_F/(1 - R_F)]$ indicated that it might be a higher homologue of the *Lolium* trisaccharide.

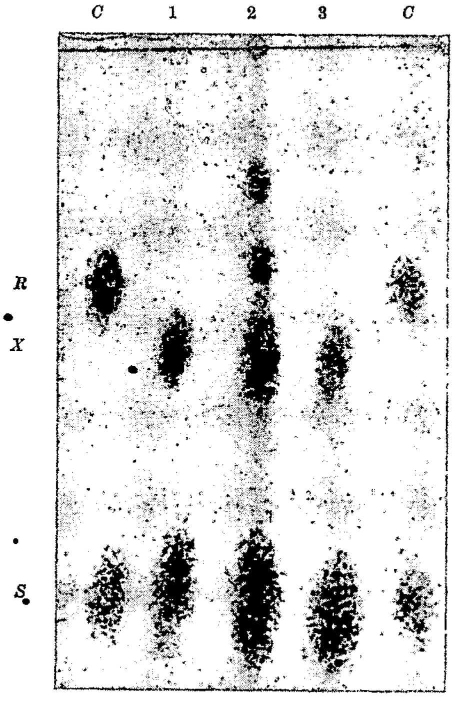

Fig. 1. Oligosaccharides of *Lolium* and *Festuca*. *C*, Control sugars; *R*, raffinose; *S*, sucrose. 1, *Lolium perenne*; 2, *Festuca rubra*; 3, *Festuca pratensis*; *X*, trisaccharide (see text). Solvent: *n*-propanol/water, 78/22

The presence of the same rather unusual trisaccharide in all species of *Lolium* and *Festuca* examined is further confirmation from a somewhat unexpected source of the close relationship of the two genera. Moreover, as far as the distribution of sugars is concerned, the affinities of *Lolium* lie with *F. pratensis* and its allies rather than with *F. ovina*, which has a more complicated pattern of oligosaccharide distribution.

We wish to express our thanks to Dr. Mary Noble, Plant Pathology Station, East Craigs, Edinburgh, for a supply of *Lolium temulentum* and to Mr. L. S. Cobley, Edinburgh and East of Scotland College of Agriculture, for samples of *Festuca*.

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[1] MacLeod, A. M., and McCorquodale, H., *New Phytol.*, **57**, 168 (1958).

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Populations of *Agrostis* spp. Tolerant of Heavy Metals

A NUMBER of collections of *Agrostis tenuis* and *A. stolonifera* have been obtained from sites contaminated by heavy metals. Some of these have been tested for tolerance of four metals, copper, nickel, zinc and lead, using as controls populations from more normal habitats. The method used in testing is derived from that of Wilkins[1]. The amount of root growth in solutions containing the heavy metals is expressed as a percentage of that in solutions containing none. All culture solutions contained 1 gm./l. hydrated calcium nitrate. The copper and lead were present as nitrates, the zinc and nickel as sulphates. The results are shown in Table 1, each figure being a mean value for 20 plants in two replicates.

The populations are numbered 1–8 as follows: 1, A population of *A. alba* (identified as *A. stolonifera* L.) from a site at Piésky, Slovakia, described by Prát[2] as soil enriched in copper by a stream flowing from an old copper mine (provided by Prof. Fott and Dr. Jan Futák). 2, Population *D* of *A. stolonifera* from Port Meadow, Oxfordshire[3]. 3, *A. tenuis* from a copper-poisoned soil in an old mining area near Parys Mountain, Anglesey. 4, *A. tenuis* grown from seed provided by Dr. W. Krause, and described by him as being from the 'poison spot' of an old nickel mine in the Black Forest. 5, *A. tenuis* also provided by Dr. Krause, seed obtained from normal heath and

Table 1. ROOT GROWTH IN TOXIC SOLUTION AS A PERCENTAGE OF NORMAL GROWTH

Concentration (micromoles/l.)		Population							
		1	2	3	4	5	6	7	8
Cu	5	72	4	83	66	7	4	34	4
	10	40	0	49	51	6	1	12	0
	15	20	0	32	29	1	0	4	0
Ni	5	27	12	50	103	43	60	50	30
	10	9	2	11	84	18	43	19	9
	15	4	0	3	70	4	14	10	0
Pb	75	26	18	37	27	16	22	80	28
	125	17	9	20	22	10	18	62	12
Zn	20	37	38	61	65	35	54	54	34
	40	21	17	33	42	19	38	48	21
	60	8	4	24	23	10	27	30	13

near the mine. 6, *A. tenuis* from a mine spoil-heap in North Wales, at first thought to contain lead, but now known to contain no significant amount of lead, but some zinc and possibly other metals. 7, *A. tenuis* from Goginan mine, Cardiganshire, previously described as resistant by Bradshaw[4]. The soil contains lead and zinc in toxic amounts. 8, *A. tenuis* from a meadow near Capel Bangor, Cardiganshire.

Each population except 2, 5 and 8, which were the controls, shows a marked degree of resistance to poisoning by the metals known to be present on the sites from which they were collected. The rather high degree of tolerance shown by the control 5 to nickel may be due to it having been grown in the same container as 4, which may have been removing a significant amount of nickel from the solution. However, without information as to how close to the mine the seed was taken, the possibility of some gene-flow from the nickel-resistant population cannot be eliminated.

A lesser degree of tolerance is also shown, in general, to other metals not known to be present. In the absence of detailed soil analyses, which are proceeding, the presence of other metals in the soil is possible, but it is suggested that the tolerance shown is due to an extension of the resistance mechanism operative against the main toxic agent. Population 6 is rather a special case, but seems to show its main resistance to nickel, although this is not so marked as in the Black Forest population.

On these sites the plant cover is generally very poor, especially where the calcium content is low, and very few species can cope with such an extreme environment. It is notable that two closely related species have proved capable of adapting themselves to meet these conditions with respect to a number of metals in several localities during the short time in which the sites have been available. The necessary genetic variation seems to be present in the genus *Agrostis* throughout a large part of its range.

The order of toxicity shown is copper > nickel > zinc > lead, which agrees with that given by Hewitt[5] and De Kock[6] for a range of plants, and also follows the Mellor–Malley series[7] for the order of stability of metallic-organic complexes. Furthermore, there are indications that the greater the degree of toxicity the more clear cut is the tolerance of it, excluding zinc, where no highly resistant population has yet been found. This lends support to the hypothesis that the resistance is due to the metal ions being bound internally by a process analogous to chelation; such a process would be most effective where the chelates are most stable. This would also explain the high concentrations of toxic metals in plants from poisonous sites noted by various authors[8,9].

However, unlike chelation the process is fairly specific for individual metals. Where activity is shown against lead, a lesser activity is shown against copper; not a higher as would be expected from the series quoted above. The advantage of this to the plant is apparent, in that it does not have micronutrient ions, which may not be abundant, made unavailable internally. If the plants have succeeded in elaborating a series of compounds capable of specific chelation, further study may be rewarding.

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July 16.

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[2] Prát, S., *Ber. Deutsch. Bot. Ges.*, **52**, 65 (1934).
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Fleas of the Rat in Tanganyika

THE flea records presented here have been based on a two-year study of *Rattus rattus* (L.), the commensal rodent of Tanganyika. No previous list of the flea fauna of *R. rattus* of Tanganyika is known. In all 1,788 specimens of *R. rattus* were obtained and their fleas collected.

The term *Rattus rattus* (L.) used here is one of convenience and embraces the very mixed, interbred population formed of strains of *R. r. rattus*, *R. r. frugivorus*, *R. r. alexandrinus* and *R. r. wroughtoni*, that is peculiar to Tanganyika and perhaps to other parts of East Africa.

Table 1

Fleas	No. collected	Percentage of collection
Xenopsylla brasiliensis (Baker)	723	71·72
Xenopsylla cheopis (Rothschild)	220	21·72
Leptopsylla aethiopicus (Rothschild)	18	1·77
Ctenocephalides felis strongylus Jordan	16	1·58
Echidnophaga gallinaceus (Westwood)	12	1·18
Dinopsyllus longifrons lypusus J. and R.	7	0·69
Pulex irritans Linnaeus	6	0·59
Ctenophthalmus cabirus Jordan	6	0·59
	1,008	

The dominant species, *X. brasiliensis*, was distributed and was dominant in urban and rural areas from sea-level to 6,000 ft., whereas *X. cheopis* was not found above 4,000 ft. *P. irritans* and *Ct. f. strongylus* were fleas of urban rats, but *D. l. lypusus*, *L. aethiopicus* and *Ct. cabirus* were confined to rats from the rural areas. The cosmopolitan *E. gallinaceus* was found in both urban and rural areas.

My thanks are due to the Director of Medical Services, Tanganyika, for permission to publish this communication; and to Dr. B. de Meillon, of the South African Institute for Medical Research, and Mr. G. H. E. Hopkins, of the Zoological Museum, Tring, for identification of the fleas.

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FORTHCOMING EVENTS

*(Meeting marked with an asterisk * is open to the public)*

Monday, September 22

Institution of Mining and Metallurgy (at the Royal Institution, 21 Albemarle Street, London, W.1), at 5.30 p.m.—Dr. Anton Gray: "The Future of Mineral Exploration" (Fourth Sir Julius Wernher Memorial Lecture).

Tuesday, September 23

Radar and Electronics Association (at the Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2), at 7 p.m.—Mr. James Moir: "Stereophonic Sound Systems".

Tuesday, September 23—Wednesday, September 24

Institution of Mining and Metallurgy (in co-operation with the United Kingdom Metal Mining Association, at 21 Tothill Street, London, S.W.1), at 10 a.m. daily—Symposium on "The Future of Non-Ferrous Mining in Great Britain and Ireland".

Tuesday, September 23—Thursday, September 25

Institution of Mechanical Engineers (at 1 Birdcage Walk' London, S.W.1)—International Conference on "Gearing".

Wednesday, September 24

British Institution of Radio Engineers (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1), at 6.30 p.m.—Mr. A. I. Godfrey: "Statistics in Radio and Television Manufacture".

Society of Chemical Industry, Plastics and Polymer Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Prof. M. Szwarc (Syracuse University): "'Living' Polymers".

Oil and Colour Chemists' Association, London Section (joint meeting with the Society of Dyers and Colourists, at the Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 7 p.m.—Dr. J. L. Moilliet: "Surface Activity—the General Concept and some Consequences".

Wednesday, September 24—Friday, September 26

Institute of Petroleum Hydrocarbon Research Group—Mass Spectrometry Panel, and Committee E-14 of the American Society for Testing Materials in the Beveridge Hall, Senate House, University of London, Gower Street, London, W.C.1)—Conference on "Mass Spectrometry".

Wednesday, September 24—Friday, October 3

Industrial Fuel Efficiency Exhibition (at the National Hall, Olympia, London).*

Thursday, September 25, Friday, September 26, Tuesday, September 30 and Wednesday, October 1, from 10.30 a.m. to 12.30 p.m. daily—Series of Technical Meetings on "Lower Costs and Higher Production through Better Fuel Utilization".

Thursday, September 25—Friday, September 26

Institute of Biology (in the Lecture Hall, Royal Geographical Society, Kensington Gore, London, S.W.7), at 10 a.m. daily—Symposium on "The Effects of Pollution on Living Material".

Friday, September 26—Saturday, September 27

Institute of Physics, Electronics Group (at University College, London, W.C.1)—Meeting on "Solid State Memory and Switching Devices".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Assistant Resident Supervisor (with a degree in agriculture and a special interest in animal husbandry) for Certificate Courses in Agriculture—The Secretary, The North of Scotland College of Agriculture, 41½ Union Street, Aberdeen (September 23).

Research Assistant (graduate in bacteriology) in Chemistry, to carry out routine growing of micro-organisms in connexion with a biosynthesis programme—The Registrar, The University, Manchester (September 29).

Senior Lecturer or Lecturer in Botany—The Registrar, The University, Manchester (September 30).

Lecturer (with a medical qualification) in Bacteriology at the Royal Infirmary, Glasgow—The Secretary of University Court, The University, Glasgow (October 10).

Lecturer (with an honours degree in mathematics or mathematical physics, lecturing experience, and preferably experience in some aeronautical subject and/or numerical methods) in the Department of Mathematics—The Recorder, The College of Aeronautics, Cranfield, Bletchley, Bucks (October 11).

Keeper of the Department of Geology—The Director, National Museum of Wales, Cardiff (October 24).

Chair of Solid State Physics tenable at the Imperial College of Science and Technology—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 27).

Lecturer in Physiology—The Secretary, The University, Aberdeen (October 31).

Lecturer in Psychology at the University of Western Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer or Assistant Lecturer in Biochemistry at the University of Malaya, Singapore—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 31).

Lecturer/Senior Lecturer in Pathology at the University of Sydney, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Lecturer (with a degree in science or agricultural science and interests in the fields of physical and inorganic chemistry) in Agricultural Chemistry (Physical and Inorganic) at the University of Queensland, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

Chair of Electrical Engineering tenable at King's College, Newcastle-upon-Tyne—The Registrar, University Office, 46 North Bailey, Durham (November 15).

Lecturer in Physics, and a Senior Lecturer or Senior Research Fellow in Theoretical Physics at the University of New England, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, November 28).

Ralston Professor of Zoology at the University of Tasmania, Australia—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, December 15).

Agronomist at the West African Institute for Oil Palm Research, for research work on the cultivation of the oil palm; and Plant Physiologists (2), one to review present methods of production and initiate ways of increasing the supply of palm wine, and the other to carry out leaf analysis and other investigations into the nutrition of the oil palm—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/199/013.

Assistant Lecturer (Grade B) in Electrical Engineering, to assist in courses for O.N.C. and H.N.C. in electrical engineering; and an Assistant Lecturer (Grade B) in Applied Physics, for O.N.C. course developing to H.N.C. level in Session 1959–60—The Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants.

Assistants (either sex, with a good reading knowledge of Russian or Italian, and preferably scientific interests), for abstracting papers in economic entomology—The Director, Commonwealth Institute of Entomology, 56 Queen's Gate, London, S.W.7.

Biochemist, basic grade (A.R.I.C. or B.Sc. with honours in chemistry or biochemistry)—The House Governor, Queen Elizabeth Hospital, Edgbaston, Birmingham 15.

Lecturer (with a good honours degree in chemistry or F.R.I.C.) in Inorganic Chemistry at Coventry Technical College—Director of Education, Council Offices, Coventry.

Research Assistant (with a good first degree in botany or horticulture, and preferably research experience and a higher degree), for work on the physiology of flowering in carnations—Prof. O. V. S. Heath, Department of Horticulture, The University, Reading.

Scientific Officer (with a first- or good second-class honours degree), to lead a section applying the techniques of gamma-ray spectrometry to the analysis of radioactive material and to expand the programme—Group Recruitment Officer (1193/34), United Kingdom Atomic Energy Authority, Atomic Energy Research Establishment, Harwell, Didcot, Berks.

Technical Research Assistant in the Physiology Department—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Guide to Evening Classes in Middlesex, Session 1958–59. Pp. 48+4 plates. (London: Middlesex County Council Education Committee, Education Offices, 1958.) [227

University Grants Committee. Returns from Universities and University Colleges in receipt of Treasury Grant, Academic Year 1956–1957. Pp. 50. (Cmnd. 477.) (London: H.M. Stationery Office, 1958.) 4*s*. net. [227

Biochemical Pharmacology, Vol. 1, No. 1 (July, 1958.) Pp. 104. Subscription (including postage): (A) £6 (U.S.A. 17 dollars) per volume; (B) for subscribers certifying that the journal is for their own personal use—£5 5*s*. (15 dollars) per annum. Four issues per volume. (London: Pergamon Press, 1958.) [227

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Twenty-eight lectures commencing Wednesday, October 1, at 6.30 to 9 p.m. By G. C. STALKER, M.A.(Edin.), M.A. (Cantab).

(d) INTRODUCTION TO THE MATHEMATICAL THEORY OF ELASTICITY AND PLASTICITY.

Twenty lectures commencing Tuesday, September 30, at 7 to 9 p.m. By D. E. R. GODFREY, M.Sc., Ph.D., A.F.R.Ae.S.

(e) FUNCTIONS AND METHODS OF MATHEMATICAL PHYSICS.

Twenty-eight lectures commencing Tuesday, September 30, at 6.30 to 9 p.m. By—Lecturer to be appointed.

(f) ELECTRO-MAGNETIC THEORY.

Twenty-eight lectures commencing Monday, September 29, at 6.30 to 9 p.m. By K. E. PITMAN, M.Sc., A.R.C.S.

(g) ELECTRONICS FOR MECHANICAL ENGINEERS.

Twenty lectures commencing Monday, September 29, at 7 to 9.30 p.m. By K. B. REED, B.Sc., A.M.I.E.E.

(h) INTRODUCTION TO SERVO-MECHANISMS.

Twenty lectures commencing Tuesday, September 30, at 7 to 9.30 p.m. By K. B. REED, B.Sc., A.M.I.E.E.

(i) NUCLEAR PHYSICS.

Twelve lectures commencing Wednesday, October 29, at 7 to 9 p.m. By K. V. HYDE, B.Sc.

(j) RECENT ADVANCES IN SYNTHETIC ORGANIC CHEMISTRY.

Six lectures commencing Tuesday, October 21, at 7.15 to 8.30 p.m. By R. SLACK, M.A., D.Phil.

(k) PESTS OF FOODSTUFFS AND STORED PRODUCTS.

Twelve lectures commencing Monday, October 6, at 6.30 to 8 p.m. By C. S. WOOD-BAKER, M.Sc., Ph.D., F.Z.S., F.R.E.S.

(l) INSECT PESTS AND FUNGAL DISEASES IN HORTICULTURE AND MARKET GARDENING.

Twenty-four lectures commencing Monday, October 6, at 6.30 to 8 p.m. By G. M. BROWN, B.Sc., A.R.C.S., and C. S. WOOD-BAKER, M.Sc., Ph.D., F.Z.S., F.R.E.S.

(m) MICROSCOPY AND ITS APPLICATIONS.

Twelve lectures commencing Monday, October 6 at 7 to 9 p.m. By H. HEYWOOD, D.Sc.Eng., Ph.D., A.C.G.I., F.R.Micr.S., Wh.Sch., M.I.Mech.E., M.I.Chem.E., A. J. HOLLOWELL, B.Sc., and others.

(n) DISEASES AND PESTS OF TIMBER.

Eight lectures commencing Thursday, October 23, at 6.30 to 8 p.m. By C. S. WOOD-BAKER, M.Sc., Ph.D., F.Z.S., F.R.E.S.

(o) PROBLEMS IN ADVANCED METROLOGY.

Six lectures commencing Wednesday, November 5, at 7 to 9 p.m. By B. FERGUSSON, B.Sc.Eng., Ph.D., A.M.I.-Mech.E.

(p) WELDING AND PLASTICS FOR PLUMBERS' WORK.

Eight lectures commencing Monday, September 22, at 7 to 9 p.m. By W. R. BURCHMORE, M.R.San.I.

(q) PUNCHED CARDS IN OFFICE AND FACTORY.

Eight lectures commencing Wednesday, October 8, at 7 to 9 p.m. By L. R. CRAWLEY, M.O.M.A., M.S.I.E., A.M.I.I.A., A.I.Prod.E.

(r) INDUSTRIAL RELATIONS TO-DAY.

Eight lectures commencing Wednesday, October 8, at 7 to 9 p.m. By MARY S. COUSINS, M.A., Dip.Social Studies, M.I.P.M.

(s) RECENT CHANGES IN CONSTITUTIONAL LAW.

Eight lectures commencing Thursday, October 9, at 7 to 9 p.m. By—Lecturer to be appointed.

(t) ORGANIZATION AND METHOD IN THE MODERN OFFICE.

Eight lectures commencing Friday, October 10, at 7 to 9 p.m. By H. W. S. MEAD, A.C.W.A.

(u) DESIGN AND FORM OF INDUSTRIAL PRODUCTS.

Six lectures commencing Monday, November 3, at 7.30 to 9.30 p.m. By Leading Industrial Designers.

(v) MODERN ART.

Six lectures commencing Thursday, November 6, at 7.30 to 9.30 p.m. By Well-known writers and critics.

FEES: Courses (b), (c), (d), (e), (f), (g), (h), (l), £2.
Courses (i), (k), (m), (n), (p), (q), (r), (s), (t), £1.
Courses (a), (j), (o), (u), (v), 10s.

ENROLMENT: By personal application from 9 a.m. to 8.30 p.m. or by postal application to the Secretary.

Middlesex County Council Education Committee

BRUNEL COLLEGE OF TECHNOLOGY,
WOODLANDS AVENUE, ACTON, W.3

Principal: Dr. J. Topping, M.Sc., Ph.D., D.I.C., F.Inst.P.

DEPARTMENT OF PHYSICS

Head of Department: C. A. Hogarth, B.Sc., Ph.D., A.Inst.P.

EVENING LECTURES—AUTUMN 1958

DISLOCATIONS IN SOLIDS

Thursdays—6.30 to 7.45 p.m. Twelve lectures commencing September 25, 1958.
Lecturer: R. L. BELL, B.Sc., Ph.D., Lecturer in Metallurgy at Imperial College

BIOLOGICAL EFFECTS OF NUCLEAR AND ALLIED RADIATIONS

Tuesdays—7.30 to 8.45 p.m. Six lectures commencing October 21, 1958.
Lecturer: E. A. WRIGHT, M.D., M.R.C.P., University Reader in Pathology at St. Mary's Hospital Medical School

ULTRASONICS

Wednesdays—6.30 to 9.30 p.m. Twenty lectures commencing October 8, 1958.
Lecturer: J. BLITZ, M.Sc., A.Inst.P., Lecturer in Physics, Brunel College of Technology

X-RAY CRYSTALLOGRAPHY

Tuesdays—6.30 to 9 p.m. Ten lectures commencing September 30, 1958.
Lecturer: J. I. MITCHELL, M.Sc., A.Inst.P., Lecturer in Physics, Brunel College of Technology

THE PHYSICS OF NUCLEAR ENGINEERING

Mondays—6.30 to 8.30 p.m. Thirty lectures commencing October 6, 1958.
Lecturer: J. W. WARREN, M.Sc., Ph.D., Senior Lecturer in Physics, Brunel Colege of Technology

AN INTRODUCTION TO THE PHYSICS OF TRANSISTORS

Mondays—6.30 to 7.30 p.m. Nine lectures commencing October 6, 1958.
Lecturer: C. A. HOGARTH, B.Sc., Ph.D., Brunel College of Technology.

C. E. GURR, M.Sc., Ph.D.,
Clerk to the Governing Body.

BOROUGH POLYTECHNIC

BOROUGH ROAD, S.E.1

ELECTRONICS AT LOW TEMPERATURES

A course of 12 lectures will be given at the Borough Polytechnic on Friday evenings at 7 p.m., commencing October 3, 1958. The lectures will be given by specialists from Industry and the Universities and the aim of the course is to introduce the Physicist and Electronic Engineer to some of the recent developments in what promises to become an important field of application. Lectures will be given in Low Temperature Physics and in the management of a low temperature laboratory as well as in the practical electronics applications.

Further information and application form may be obtained from the Secretary.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

LONDON, S.W.7

CHEMICAL ENGINEERING DEPARTMENT

A course of four lectures on "Trapped Radicals" will be given by Dr. G. J. Minkoff on Mondays at 2 p.m., commencing October 20, 1958.

Further particulars from the Registrar, Imperial College, London, S.W.7.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

LONDON, S.W.7

CHEMICAL ENGINEERING DEPARTMENT

A course of six lectures on "The Design, Testing and Protection of Pressure Vessels" will be given by Mr. K. E. Bett on Mondays at 3.15 p.m., commencing October 20, 1958.

Further particulars from the Registrar, Imperial College, London, S.W.7.

UNIVERSITY COLLEGE LONDON, GOWER Street, London, W.C.1. Applications for B.Sc. (Special) Degree course in Chemistry, commencing October, 1959, must reach the Tutor to Science Students by December 31, 1958 (quote TS/C).—Selected applicants, who will be notified individually, will be required to attend the written examination and an interview on both Thursday and Friday, January 22 and 23, 1959, from 9 a.m. to 5 p.m.

OFFICIAL APPOINTMENTS

HAMPSHIRE EDUCATION COMMITTEE

FARNBOROUGH TECHNICAL COLLEGE

Principal: Mr. R. D. Peggs, O.B.E., M.A., M.I.Mech.E., F.R.Ae.S.

Applications are invited for the following posts:

(1) Assistant Lecturer (Grade B) in Electrical Engineering to assist in courses for O.N.C. and H.N.C. in Electrical Engineering. Industrial experience preferable.

(2) Assistant Lecturer (Grade B) in Applied Physics for O.N.C. course developing to H.N.C. level in Session 1959/60. Industrial experience preferable.

The salary for the posts will be in accordance with the Burnham Scale—Grade B (men) £650 by £25 to £1,025 with the usual allowances for training, qualifications and industrial experience, e.g., £125 for a good honours degree.

Further particulars and application forms may be obtained from the Principal, Farnborough Technical College, Boundary Road, Farnborough, Hants, to whom they should be returned as soon as possible.

R. M. Marsh. County Education Officer, The Castle, Winchester.

MATHEMATICIAN OR STATISTICIAN REquired for appointment as a Statistical Engineer in the System Operation Branch at Central Electricity Generating Board Headquarters, London, S.E.1. Duties include investigations requiring the application of advanced statistical and probability methods to engineering problems associated with the operation of a large interconnected electricity supply system, with particular reference to short-term load estimation and to the study of the effect of weather on system load. Computing assistance will be provided and access to the facilities of a large electronic computer will be available. Candidates should have a knowledge of statistics and should hold a university degree in mathematics or statistics. A knowledge of meteorology would be an advantage. Salary on a scale within the range £1,210 to £1,795 per annum according to duties and responsibilities.—Applications, stating age, qualifications, experience, present position and salary, to I. G. Ellis, Personnel Officer, 24/30 Holborn, London, E.C.1, by October 3. Please mark envelopes "Confidential" and quote ref. No. N./268.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

SOIL MECHANICS SECTION

APPOINTMENT OF SOIL STABILIZATION CHEMIST

Applications are invited for appointment to a position of Soil Stabilization Chemist with the Organization's Soil Mechanics Section located at Box Hill, Victoria. The appointee will be located in Melbourne but will be expected to observe soils and soil conditions in various parts of Australia. The Section has undertaken a major programme of research into the principles and practices of soil stabilization with particular reference to Australian soils and the Australian environment. The programme is based upon pedological concepts and is supported, in matters of pedology and soil chemistry, by the Division of Soils, C.S.I.R.O. It is proposed that each of the disciplines of soil physics, soil chemistry, and soil mechanics, as applied specifically to the problems of soil stabilization, will be developed within the Soil Mechanics Section. The appointee would be expected to take responsibility for the chemical aspects of this programme and to work in close liaison with the associated disciplines within and without the Section. If sufficiently experienced, the appointee would be expected to assume the major control, under the general direction of the Officer-in-Charge, of the work of this group. Applicants should possess a university honours degree in science with chemistry as a major subject, or equivalent qualifications. Advanced training and postgraduate research experience is desirable, particularly in the field of colloid chemistry. A familiarity with soil chemistry and a basic training in physics and/or geology would be an advantage. Dependent upon qualifications and experience, commencing salary will be determined within the salary ranges of Research Officer, £A.1,326 to £A.1,951 per annum, or Senior Research Officer, £A.2,061 to £A.2,336 per annum. Salary for a female appointee would be £A.170 per annum less than the corresponding male rates. The appointment will be conditional upon a satisfactory medical examination and confirmation of appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges. Fares to Australia, including those of wife and dependent family, will be provided by the Organization. Details may be discussed with the undersigned.

Applications, quoting Appointment No. 277/3, and stating full name, place, date and year of birth, nationality, marital state, present employment, details of qualifications and experience, and of war service, if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned, from whom further particulars may be obtained, by October 18, 1958.

E. J. DRAKE,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, W.C.2.

UNIVERSITY OF READING

Research Assistant wanted for work on the physiology of flowering in carnations. The appointment would be, in the first instance, for one year only. Candidates should have a good first degree in botany or horticulture; research experience and a higher degree an advantage. Salary between £450 and £600 per annum according to age and experience.

Applications to Professor O. V. S. Heath, Department of Horticulture, The University, Reading.

SENIOR SCIENTIFIC AND SCIENTIFIC Officers, required at Government Communications Headquarters, Cheltenham, for telecommunications and electronic research in following fields: V.H.F. receiver design and microwave techniques; propagation trials; applications of semi-conducting devices; high speed electronic switching; data storage and handling; computer programming, and operational research. Candidates must normally be natural born British subjects of natural born British parents. First- or second-class honours degree in physics, mathematics or engineering or equivalent, at least three years' postgraduate experience for Senior Scientific Officer. Salaries for men (provincial rates) Senior Scientific Officer, £1,130 to £1,330; Scientific Officer, £595 to £1,050 (according to age and qualifications). Appointments unestablished but opportunities to compete for established posts.—Forms from Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A147/8A.

ESSEX EDUCATION COMMITTEE

MID-ESSEX TECHNICAL COLLEGE

MARKET ROAD, CHELMSFORD

The following teachers are required in the Science Department from January, 1959:

(a) Senior Lecturer in Applied Physics. Candidates should hold a good honours or higher degree, be corporate members of the Institute of Physics, and having teaching as well as industrial and/or research experience.

Salary scale: £1,350 by £50 to £1,550 per annum.

(b) Lecturer in Physics. Candidates should have a good honours degree or equivalent, together with teaching, research, or industrial experience, and be able to offer specialized knowledge of a branch of Applied Physics.

Salary scale: £1,200 by £30 to £1,350 per annum.

(c) Assistant, Grade B, for Mathematics. Applicants should be graduates, and some previous teaching experience is desirable. Duties will involve work in Degree and H.N.C. courses.

Salary: £650 by £25 to £1,025 with additions for graduation (or equivalent) and approved training. Increments within scale for previous teaching service, approved industrial experience and War/National Service.

Details and application forms (stamped addressed foolscap envelope) from the Clerk to the Governors at the College.

UNIVERSITY OF BIRMINGHAM

DEPARTMENT OF CHEMISTRY

Applications are invited for a National Coal Board Postdoctoral Fellowship in Physical Chemistry. The research work to be undertaken is connected with the study of solids by a number of techniques such as mass spectroscopy. The salary will be £700 to £800 per annum according to age and experience.

Applications (two copies) should be sent not later than October 31, 1958, to the Registrar, the University, Edgbaston, Birmingham, 15.

IMPERIAL COLLEGE OF SCIENCE AND TECHNOLOGY

LONDON, S.W.7

Research physicist or engineer, preferably with knowledge and aptitude for hydrodynamics, required to undertake model research on fluid flow. Work could lead to higher degree. Salary £450 to £850 per annum, according to experience.

Apply, with names of two referees, to Meteorology Department.

FOURAH BAY COLLEGE

UNIVERSITY OF DURHAM

SIERRA LEONE

Applications are invited for the post of Senior Lecturer or Lecturer in Geography. Qualifications: good honours degree and teaching experience. Salary scale: Senior Lecturer, £1,700 by £75 to £2,150; Lecturer, £965 by £50 to £1,365; E.B., £1,415 by £75 to £1,715. Entry point according to qualifications and experience. Other conditions include children's allowances (maximum £300), passages on appointment and annual leave, part-furnished accommodation at rental not exceeding 7½ per cent of salary.

Further information from Secretary, Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2, to whom applications (six copies) giving age, qualifications, and experience and naming three referees should be sent by October 6, 1958.

UNIVERSITY OF DURHAM

Applications are invited for the post of Assistant Appointments Officer. The person appointed will be concerned with students and graduates in science and also probably agriculture. Candidates should have a degree, preferably in science, and experience of work in fields where graduate scientists are commonly employed. Starting salary will be within the range £900 by £50 to £1,350 (bar), the scale then rising to £1,650. F.S.S.U. membership is compulsory.

Further particulars of the post may be obtained from the Registrar of the University at 46 North Bailey, Durham, with whom twelve copies of application should be lodged not later than September 27, 1958. (Candidates outside the British Isles may submit one copy only.)

NATIONAL INSTITUTE FOR RESEARCH IN DAIRYING

(UNIVERSITY OF READING)

Assistant for Information Service. Duties include assisting with public relations activities, subediting, and internal information work. Applicants preferably should hold a science degree, and a knowledge of languages would be an advantage. Appointment will be made within Assistant Experimental Officer grade: £478 per annum (at age 21) to £645 (at age 26 or over), scale maximum £800 scale for women slightly lower. Pension scheme.

Applications, naming two referees, to Secretary, N.I.R.D., Shinfield, Reading. Quote ref. 58/25.

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

MATHEMATICIAN for NUMERICAL ANALYSIS

A Mathematician interested in the development of methods of Numerical Analysis is required for a senior post which carries responsibility for all the research in numerical analysis at Aldermaston The computing equipment available is unique in Great Britain and includes an I.B.M. 704, a Deuce, and a Ferranti Mark 1*.

Candidates should have a first-class honours degree in Mathematics; preference will be given to those whose experience of Numerical Analysis has been particularly concerned with partial differential equations.

The salary paid will be in the range £2,200–£2,600 p.a. Contributory superannuation scheme. A modern house with garage will become available for married officers living beyond daily travelling distance.

Please send a postcard for application forms to

The Senior Recruitment Officer,
A.W.R.E., ALDERMASTON, BERKS.
Please quote ref. No. 2024/34

CENTRAL ELECTRICITY GENERATING BOARD

COMPUTORS are invited to apply for appointment as Technical Assistant (Statistics) in the Statistics Section of the Generation Operation Branch located at Holborn, E.C.1. Salary £10 7s. to £12 5s. 6d. per week.

Candidates should have a General Certificate of Education at Advanced level in Mathematics, or equivalent, and practical experience of calculating machinery.

Applications, stating age, qualifications, experience, present position and salary, should be forwarded to I. G. Ellis, Personnel Officer, 24/30 Holborn, London, E.C.1, so as to arrive not later than September 27. Envelopes should be marked "Confidential"—Ref. N./264.

COMMONWEALTH of AUSTRALIA

COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION

DIVISIONS OF SOILS

APPOINTMENT OF PEDOLOGIST AND SOIL SURVEYOR

Applications are invited for appointment to a position of Pedologist and Soil Surveyor with the Organization's Division of Soils located at Deniliquin, New South Wales. The appointee will be required to determine which soil characteristic and value is indicative of crop suitability in particular districts and for a variety of crops. This work requires the development of a new line of investigations which will render soil surveys more serviceable. The work, initially, will be concerned with determining soil characteristics indicative of the response of irrigated pastures in N.S.W. Applicants should possess a university honours degree in science or agricultural science together with some previous research experience preferably in soils investigations. Competence in statistical techniques is desirable. Commencing salary is dependent upon the appointee's qualifications and experience and will be determined within the salary range of Research Officer, £A.1,326 to £A.1,951 per annum. Salary for a female appointee would be £A.170 per annum less than the corresponding male rates. The appointment will be conditional upon a satisfactory medical examination and an initial probationary period of up to twelve months may also be specified. Confirmation of appointment carries with it Commonwealth Superannuation Fund or Commonwealth Provident Account privileges. Fares to Australia, including those of wife and dependent family, will be provided by the Organization. Details may be discussed with the undersigned.

Applications, quoting Appointment No. 270/166 and stating full name, place, date and year of birth, nationality, marital state, present employment, particulars of qualifications and experience, and of war service, if any, together with the names of not more than four persons acquainted with the applicant's academic and professional standing, should reach the undersigned, from whom further particulars may be obtained, by October 18, 1958.

E. J. DRAKE,
Chief Scientific Liaison Officer.
Australian Scientific Liaison Office,
Africa House, Kingsway, W.C.2.

THE ROYAL COLLEGE OF SCIENCE AND TECHNOLOGY,

GLASGOW

(Affiliated to the University of Glasgow)

CHAIR OF METALLURGY

The Governors of the Royal College of Science and Technology invite applications for the Chair of Metallurgy, which will become vacant on April 1, 1959, on the retirement of the present holder, Professor R. Hay. The salary is on a scale £2,400 by £100 to £2,700. Forms of application and particulars of the appointment may be obtained from the Secretary.

THE SECRETARY OF STATE FOR SCOTland invites applications for the Regius Chair of Botany in the University of Aberdeen. The person appointed will be expected to take up his duties on October 1, 1959.—Three copies of applications, accompanied by the names of three referees, should reach the Private Secretary, St. Andrew's House, Edinburgh, 1, not later than November 10, 1958. A note of the conditions and appointment will be supplied on request.

AGRICULTURAL DEPARTMENT

TRINIDAD

ENTOMOLOGIST

To carry out research on biology and control of insect pests of coconuts and to co-operate in assessing their importance as vectors of Red Ring Disease. Candidates must have a good honours degree in Natural Science and should have had some research experience in entomology. Appointment is on contract/gratuity terms for three years in the first instance with salary in scale £950 to £1,450 per annum. Gratuity of £25 to £37 10s. for each completed period of three months' satisfactory service. Free return passages for officer, wife and children not exceeding five persons in all. Government quarters, when available, at moderate rental. House allowance payable if quarters not available.

Apply, giving brief particulars to Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD 63/38/01.

NORTHERN POLYTECHNIC

HOLLOWAY, LONDON, N.7

The Governing Body invites applications for appointment as Principal of the Northern Polytechnic. Candidates should possess high academic qualifications and appropriate educational and administrative experience. Salary scale: £2,350 rising by annual increments of £100 to £2,650 per annum, plus London allowance. Duties will commence on September 1, 1959, or such earlier date as may be agreed. The Northern Polytechnic is a major Regional Technical College. To meet current needs and to provide for future development, a large site adjacent to the Polytechnic is now being acquired for a substantial extension.

Form of application, together with full particulars, will be forwarded on request, and should be returned to me, duly completed, not later than October 31, 1958.

R. H. CURRELL, A.C.A.,
Clerk.

REACTOR PHYSICISTS

are required by the

UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(Industrial Group)

Risley, Warrington, Lancashire,

in the Central Technical Services, which is responsible for the detailed performance calculation of Industrial Group projects and for collaboration in this respect with industrial firms and Electricity Boards, undertaking nuclear work.

A number of vacancies exist in the rapidly expanding Thermal Reactor Neutronics Section which are of particular interest to men and women physicists and mathematicians who wish to enter the atomic energy industry.

The work covers many topics, including the estimation of reactor parameters, the economic aspects of nuclear power stations and the subjects of reactor kinetics and automatic control which are becoming of great significance. Close liaison is maintained with experimental work carried out at other Authority establishments and many opportunities arise for visiting these sites. Much of the work requires the use of automatic computers and a programming and computing service is being provided. A knowledge of nuclear physics or the mathematics of reactors is not essential as there are considerable opportunities for training and particular efforts are made to give each member of the staff a wide range of experience.

A first- or second-class honours degree, or equivalent, is essential.

Salary between

£1,460 and £2,080,
£1,215 and £1,425,
£645 and £1,120

according to qualifications and experience.

Good relevant research experience is essential for apointment in the higher scales.

Contributory Pension Scheme.

Housing or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting reference 2628, to Recruitment Officer at above address.

Closing date: October 13, 1958.

ASSISTANT DIRECTOR

required at the National Coal Board's Mining Research Establishment, Worton Hall, Isleworth, Middlesex. This Establishment employs some 200 scientists and technologists, a large proportion being physicists and mechanical engineers, on research, embracing all aspects of underground mining, e.g., coal winning, rock working, underground transport, strata control, environmental conditions, instruments for measurement and control and metallurgical problems.

Applicants should be Mechanical Engineers with an interest in applied mechanics, or Physicists having a good academic record with considerable experience both in research and its direction including planning, budgetary control, interpretation of results and the application of conclusions by development and user organizations.

The appointment is superannuable, and salary depending on qualifications and experience will be not less than £2,200.

Write to Staff Manager (X.1245), N.C.B., Hobart House, Grosvenor Place, London, S.W.1, stating age, education, qualifications and experience, before September 30, 1958.

UNIVERSITY OF DURHAM

KING'S COLLEGE

NEWCASTLE UPON TYNE

A Biochemical Technician is required in th Physiology Department of the Medical School, t take charge of the preparation of material for bic chemical classes for medical, dental and scienc students, and to assist, if required, in researc work of a biochemical nature. The appointmer will be on the Technician Grade (for which th salary scale is £420 to £570 per annum) or on th Senior Technician Grade (for which the sala scale is £590 to £690 per annum). The Grade t which the appointment is made, and the point c entry on the salary scale will be determined b age and experience.

Application, in writing, should be made to Pro fessor A. A. Harper, Department of Physiolog Medical School, King's College, Newcastle upo Tyne, 1.

UNIVERSITY OF DURHAM

KING'S COLLEGE,

NEWCASTLE UPON TYNE

DEPARTMENT OF PHYSIOLOGY

The Council of King's College invite applic tions for the post of Lecturer or Demonstrator i Physiology. The lecturer or demonstrator will b concerned chiefly with dental teaching, but may b asked to take part in the teaching of medical an science students. Applicants should have a med cal or dental qualification or an honours degr in physiology or biochemistry. The grade an commencing salary will be determined on the bas of the qualifications and experience of the a pointee. Appointments on the Demonstrat Grade are for one year in the first instance b renewable up to a maximum of three years. Th salary ranges are as follows: medical £700 t £1,000; non-medical, under 26, £650 to £700, ov 26, £700 to £750. There are annual increments c £100 for medical and £25 for non-medical demo strators. The salary ranges on the Lecturer Gra are as follows: medical £950 by £100 to £1,650 non-medical £900 by £50 to £1,650.

Twelve copies of application, together with th names of three persons to whom reference may b made, should be submitted not later than Octob 11, 1958, to the undersigned from whom furth particulars may be obtained.

G. R. HANSON,
Registrar of King's Colleg

NYASALAND

ASSISTANT CONSERVATOR OF FOREST

In addition to the general duties of an Assista Conservator of Forests he will also be required f practical surveying duties within Forest Reserve Candidates must have a university degree i forestry, experience or training in surveying a advantage. Appointment on probation to th permanent establishment with pensionable emol ments in scale £895 to £1,850 per annum. Fr passages on appointment and leave for officer, wif and children up to three adult passages in al Furnished quarters, normally available at modera rental.

Apply, giving brief particulars, to Director c Recruitment, Colonial Office, London, S.W.1 quoting BCD.61/4/01.

NATURE

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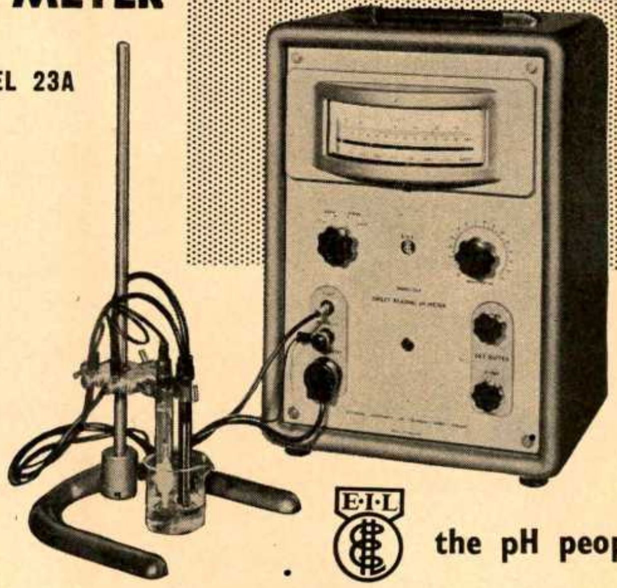

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ADMINISTRATION OF SCIENCE IN BRITAIN AND THE UNITED STATES

THE papers presented to the Sixth Conference on Scientific Manpower, held at Indianapolis last December in conjunction with the 124th annual meeting of the American Association for the Advancement of Science, have recently been published by the National Science Foundation*, with an introductory account reviewing the major developments which affected the scientific man-power situation in the United States during 1957. There was some easing of the demand for scientists and engineers during the year as a result of economic readjustment, while there were increases of about 11 per cent in the number of first-level degrees awarded in natural science and of about 19 per cent in bachelors' degrees in the engineering field in 1956–57 over the previous year. There was growing public awareness of the significance of scientific and technical training at all levels to the welfare and economic growth of the nation, and this introductory survey emphasizes that temporary shifts in the supply–demand interrelation have not altered the underlying influence of science and technology on the national economy.

It will thus be seen that many of the same points are being emphasized in the United States as have been stressed in the presidential address to the British Association and on other occasions in Great Britain, when the bearing of education on science and technology was discussed. This is particularly noticeable in the papers contributed to the Manpower Conference, the broad theme of which was "Scientists and Scientific Research in a Changing Economy". In the first of these, Y. Brozen, of the University of Chicago, discussing scientific advance as a factor in economic change, presents evidence indicating that a rapid increase in the output of scientists and expenditure on research is required if the United States is to make the best use of its savings available for investment, and that care must be taken not to stifle expenditure on scientific work directly connected with research, if the military effort is to be supported with maximum efficiency. Research which has no direct relation to defence may do more to increase military output than that directly related. He sees little need for additional Government funds for research, but suggests less Government expenditure on applied and more on fundamental research. The bottleneck in research to-day is not money but personnel.

This, too, is a point that has been made repeatedly in Britain, and it is a major reason for current concern as to the disposition of our own research effort, both pure and applied. It may be true that, as J. F. Dewhurst observes in "America's Needs and Resources", technology is a primary resource, and that without it all other resources would vanish, but it could equally be argued that science itself is the ultimate resource. Without an appropriate balance between science and technology, however, the development of both is impeded, and in such a world of technology as that we have now entered the determination of that balance grows ever more difficult.

It is a matter not simply of appropriate organization for the disposition of resources and the control of their expenditure, but increasingly of sound judgment. The first is the reason why a recently issued report of the Select Committee on Estimates is of special interest to the scientist and technologist, the second a matter of appropriate education. Both points receive attention in this series of papers, notably in the second, and largest of the six, in which Dr. J. W. Feiss, of the Kennecott Copper Corporation, reviews the new and changing activities of scientists and the implications. He suggests that the proportion of 16 per cent of scientists engaged in science teaching is too low, though accepting that in view of the greater importance of quality of teaching a figure of 15–20 per cent may be reasonable. It is equally clear that greater mobility of both the scientist and technologist should be encouraged, and this should be a definite purpose in our higher education policy to further. The education of the public is also important, and Dr. Feiss urges that scientists must increasingly discharge this responsibility through the Press, radio and television. Scientific writers are needed to interpret to the public in simple language the complex technology of to-day and supply the need for information, for guidance and answers to the questions put by the man in the street. Here the British Association, for example, might well be increasingly concerned with the effectiveness of its annual meetings and other activities in discharging such a function.

Mr. W. D. Carey's discussion of the support of scientific research emphasizes that the direction of Government support of research is, in the United States, largely in the hands of scientists themselves, but points out that, as corollary, with such power and responsibility must go a greater understanding of decision-making problems in the Government generally and a perspective of the whole within which scientists must work. Finally, he urges that the ties between Government and science require strengthening but by methods that render science and education enduring and free institutions in their own right, and this involves thinking out a comprehensive public policy for the partnership of science with Government. Prof. H. E. Langenecker's paper, "New Dimensions in Training Scientists", likewise reflects concern over the relations between Government, education and science, and particularly over the difficulty of seconciling increasing Federal support with freedom of choice, of thought and discussion. The universities and colleges are already receiving about 1,000 million dollars a year of Federal funds for purposes remote from higher education itself, and he suggests that it may be desirable to increase the allocations in some categories, such as research grants of the type where the university retains the decision at the expense of those which make the university a faculty leased by the Government to do its own work. The problem of advance planning and continuity of support so far as Federal funds for research are concerned has not yet been satisfactorily resolved, and it is also necessary to consider new forms of assistance.

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* National Science Foundation, Washington. Scientific Manpower, 1957: Papers of the Sixth Conference on Scientific Manpower. Pp. iii+46. (Washington, D.C.: National Science Foundation, 1958.)

Neither Mr. Carey, himself of the Bureau of the Budget, nor Prof. Langenecker (of the University of Illinois) expressly refers to the University Grants Committee, but it is obvious that they are considering the practicability of some device, appropriate to Federal conditions, which would strengthen the continuity and independence of fundamental research, particularly in the universities. It is interesting to note that a Government official, after expressing the opinion that in fundamental research and in other areas of development Government support, under recent conditions, has not fluctuated widely, so strongly advocates closer association of the scientist with policy and the making of decisions. None the less, the publication of the study by C. V. Kidd, of the National Institutes of Health, of the relation between Federal funds for research and the universities of America, to which Mr. Carey refers, should be of considerable interest in Britain. Apart from these questions of administration, with which both the Select Committee on Estimates and the Committee of Public Accounts have been preoccupied, there are other dangers to university work and autonomy, to which Prof. Langenecker more specifically refers, which apply equally to British universities and which, at a time of expansion and considerable stress, could be the more insidious and distorting.

Perhaps the point in Prof. Langenecker's paper which deserves to be most widely noted and considered in Britain is that in which he directs attention to what is being done for the improvement of learning and teaching. The new responsibilities and programme of the National Science Foundation appear as yet to have received comparatively little attention in Britain, but they point to possibilities that are highly significant at a time when the supply of teachers is the real bottleneck in the expansion of higher technological and of technical education—indeed, of education at all levels. Any means of making the most effective use of a limited and indeed scarce resource should be explored as carefully and urgently as the possibilities of expanding the supply, and it is the note of urgency with which the shortage is being tackled in the United States as well as the novelty and range of the efforts being made to improve the situation that should compel examination in Britain in the light of our own needs and conditions.

Of the remaining papers it should suffice to note that R. D. Bennett, of the General Electric Company, considers very briefly the contribution of large research centres to the training of scientific workers. Qualitatively this does not differ greatly in the United States from the contribution they make in Britain, but its dependence upon an adequate educational basis in the schools is emphasized. The concluding paper, by T. J. Mills, of the National Science Foundation, on comparative salary-levels of scientists deals with United States conditions and is admittedly incomplete. Geologists, physicists and meteorologists appear to be the higher paid scientists on the average, astronomers, mathematicians, biologists and psychologists coming at the other end of the scale; comparative data for chemists were not available. Some doubt is expressed whether the material rewards of a scientific or technical career are sufficient to ensure a continuing flow of new entrants in the numbers necessary to maintain or increase the supply.

COLLECTED WORKS OF MAX PLANCK

Physikalische Abhandlungen und Vorträge

Von Max Planck. (Aus Anlass seines 100 Geburtstages (23 April 1958), herausgegeben von dem Verband Deutscher Physikalischer Gesellschaften und der Max-Planck-Gesellschaft zur Förderung der Wissenschaften e.V.) Band 1: Pp. xv+776. Band 2: Pp. xi+716. Band 3: Pp. xii+426. (Braunschweig: Friedr. Vieweg und Sohn, 1958.) 150 D.M.

THIS work, consisting of three large volumes, has been published to celebrate the one hundredth birthday of Max Planck, one of the greatest men of science of all time. It contains his published scientific papers and the lectures and addresses which he delivered on various occasions, as well as a few addresses given in his honour by such distinguished men as Sommerfeld, Debye, von Laue and others.

It is beautifully produced, as indeed one would expect, coming as it does from the famous old firm of Friedr. Vieweg und Sohn in Brunswick. As von Laue indicates in his short preface, Planck began by an intensive study of the work of Rudolph Clausius, who introduced the notion of 'entropy' and who, it may be said parenthetically, was greatly influenced by Clapeyron (*vide* p. 123 of Browne's translation of "Mechanischetheorie der Wärme").

Most of the papers in Vol. 1, though not all of them, deal with thermodynamics, and there is no doubt that long reflexion on thermodynamical problems prepared the way for Planck's crowning achievement: the solution of the problem of the distribution of energy in the normal spectrum and the associated discovery of the elementary quantum of action.

Looking back, one can now appreciate that if Planck had known and attached any value to Hamilton's discovery of the identity in form of the laws of geometrical optics and those of (Newtonian) mechanics he might indeed have discovered wave mechanics by extending the identity in form from the narrow domain:

[geometrical optics]——[Newtonian mechanics]

to the more extensive domain:

[optics in the widest sense]——[an appropriately widened type of mechanics]

Until Born suggested, correctly as I believe, that the wave formulæ in quantum mechanics are simply expressions of probabilities, Planck, like everyone else, found insuperable difficulties in reconciling the corpuscular features, for example, of light, with its very marked undulatory characteristics. This appears in a paper on the synthesis between wave mechanics and corpuscular mechanics, published in 1940 (*vide* Vol. 2, p. 685). Naturally he could not then appreciate the significance of the fact that the corpuscular aspect only appears when sufficiently small numbers of particles are involved and the wave phenomena (as in Sir Geoffrey Taylor's experiments) when enormous numbers are dealt with. With enormous numbers probabilities approach certainties, as the success of insurance companies indicates.

At the end of Vol. 3 is the address delivered by Max von Laue at Planck's graveside, some personal memories of Planck by Dr. Otto Hahn, and a short essay on his life-work by von Laue.

As the originator of the quantum theory Planck's fame will endure and his name will always rank with those of Newton, Clerk Maxwell and Einstein. But there is something more to be said about him: he was a kindly, good man—a great gentleman who endured patiently and bravely the sorrows and suffering which overwhelmed him in his later life. He was a real friend to me and I shall always remember one of his favourite sayings:

"Man muss Optimist sein". W. WILSON

OPERATIONAL RESEARCH

Proceedings of the First International Conference on Operational Research, Oxford, 1957

(Organized by the Operational Research Society, United Kingdom; The Operations Research Society of America; and the Institute of Management Sciences.) Pp. viii + 526. (London: English Universities Press, Ltd., 1957. Published for the Conference Committee.) 50*s*. net.

THIS volume is one that no professional operational research worker can be without, for it gives a very wide sample of the types of problems which he may be likely to be called upon to deal with. It has already become a recognized source book in the short period since publication. Not the least valuable parts of it are the references to earlier work and the discussions, which have been kept commendably brief.

The volume may possibly leave a stronger impression than is desirable that operational research is not much more than applications of advanced mathematical and statistical methods to decision problems. On the other hand, the methodology of operational research is much more mathematical and statistical than general scientific; this conference was methodological, and so it is not surprising that the published matter exhibits apparent bias.

A weakness in industry is to think of operational research as solving problems which require these advanced methods (these are the cases which, incidentally, can usually be published without breach of confidence) and excluding the class of problems which can be resolved by much simpler techniques. An enormous amount of progress can be made with little more mathematical equipment than the elements of the theory of functions, for after all what is a business enterprise but a mathematical function when represented in a form suitable for analysis.

A curious feature of the Conference Proceedings is that almost everywhere in the world military operational research seems to be ahead of industrial work. This is understandable in countries which were involved in military operational research during 1939–45. It is, however, less understandable in other countries.

This is not a work for business executives, unless they happen to be well equipped with a knowledge of mathematics and statistics. Perhaps this is unfortunate, but after all the object of the Conference was to aid the operational research scientist, rather than the employer. It is to be hoped, however, that much more attention will in future be devoted to educating the potential customer. British industry is undoubtedly making quite insufficient use of the men available who can apply scientific methods to problems at all levels from the board room to the shop floor.

The standards of printing and layout of the book leave nothing to be desired. K. PENNYCUICK

THEORY OF ROCKET FLIGHT

Exterior Ballistics of Rockets

By Prof. Leverett Davis, Jr., James W. Follin, Jr., and Prof. Leon Blitzer. Pp. v + 457. (Princeton, N.J.: D. Van Nostrand Company, Inc.; London: D. Van Nostrand Company, Ltd., 1958.) 64*s*.

THIS book expounds the mathematical theory of the motion of unguided rockets stabilized either by fins or by spin, and launched either from the ground or from an aircraft. After defining the force-system the authors formulate the equations of motion and solve them under the usual approximation of constant acceleration, to obtain the ideal trajectory and to show the errors arising through malalignment of thrust, the action of gravity and wind, tip-off effects as the rocket leaves the launcher, and the various other hazards which mar the accuracy of this type of missile. The book ends with a useful collection of formulæ and tables of Fresnel functions.

The theory presented in the book was developed in the United States during and just after the Second World War, but the final report on the work was not printed until 1953. Before open publication was allowed, various items had to be deleted, and the authors also made corrections and a few additions. The book has been reproduced from the 1953 report thus modified, by a photo-offset process. One beneficial result of this procedure is that there are very few misprints: so high is the standard that the mis-spelling of Jeffreys on p. 166 comes as quite a shock. The authors write well, and they develop the theory in a logical order, fully explaining the physical basis for each step in the argument. The result is a book which is unlikely to be superseded for many years. Its value is enhanced by the pleasing layout and by the clarity of the print, especially the mathematical symbols and the diagrams (though there are a few messy diagrams, one of which seems to be a freehand sketch). Many footnotes have been deleted because they refer to classified material, and the frequent gaps at the bottoms of pages are a mute memorial to the many workers whose contributions to the theory will remain generally unknown.

The long delay in the final publication of the book inevitably detracts a little from its worth. For example, the list of rockets for which design details are given has an air almost of antiquity, and it is noticeable that very few of the references are later than 1947. Also it is obvious that the book was virtually complete before the publication in 1949 of Rankin's "Theory of the Motion of Rotated and Unrotated Rockets", which indeed does not appear among the footnotes until p. 433, though it covers much of the same ground. Those who are familiar with Rankin's monograph will find that the book under review does not go so deeply into the fundamentals, and mathematically it is less rigorous; but there is a much fuller explanation of the physical processes and more linking narrative. Indeed, the authors are to be congratulated on producing a book which, as well as being authoritative, is, considering the difficulty of the subject, easy to read.

D. G. KING-HELE

PROGRESS IN CHEMICAL ENGINEERING

Advances in Chemical Engineering, Vol. 2

Edited by Thomas B. Drew and John W. Hoopes, Jr. Pp. x+338. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1958.) 9.50 dollars.

THE second volume of this work follows the same general pattern as the first (*Nature*, 179, 503; 1957) and includes chapters on six unrelated topics, some of which are of predominant interest to the chemical engineer, whereas others should command a wider range of readers. Nor are all the chapters written at the same level; some assume a considerable prior knowledge of the subject, whereas others start with the elementary concepts and are occasionally superficial in their approach. The general impression is again that most of the items would more usefully have been published as individual monographs, in order to obviate the necessity for the reader to buy much material that he does not require. In this connexion, the publishers are considerably at fault in splitting the contribution on boiling liquids between the two volumes.

The first chapter follows on naturally from the material on boiling liquids in Vol. 1, and deals particularly with transition and film boiling, on which subjects there is far less published work than on nucleate boiling. The approach is somewhat factual and uncritical. The chapter concludes with sections on localized boiling in liquid the bulk of which is below its boiling point, and on bumping, which apparently takes place only in laboratory-scale apparatus.

Automatic process control is treated from a fundamental point of view, which will be of value to the newcomer in the field. The theory of control and different types of control action are discussed, but no reference is made to the instruments which are used, nor are there any practical examples related to chemical engineering problems.

The following chapter is entitled "Treatment and Disposal of Wastes in Nuclear Chemical Technology". It includes a general discussion of disposal problems with special reference to the geological and climatic requirements of the site. Methods of concentration before disposal are considered, and the concluding section refers to the recovery of fission products.

The chapter on high-vacuum technology tends to be a little superficial. Following a historical account of the development of the subject, there is a brief account of the flow of gases at low pressures, with special reference to the transition between molecular and laminar flow. Convective heat and mass transfer at low pressures are discussed and the chapter concludes with a short description of some common types of vacuum pumps and gauges.

An extensive treatment of separation by adsorption methods is particularly welcome because of the lack of a satisfactory literature on the subject. The discussion embraces the fields of ion exchange and chromatography, and particular attention is paid to the effect of the shape of the adsorption isotherm on the process.

The final chapter on the mixing of solids covers the subject in considerable detail. The problems of sampling and the statistical significance and interpretation of analyses are taken first. Perfect mixing is effected when the probability of finding a particle of a given type is the same at all points and is equal to the proportion of particles of that type in the mixture. There is a useful treatment of Weidenbaum's and Lacey's approach to mixing as an unsteady-state diffusional problem. The various types of mixer are considered in relation to the type of motion imparted to the particles, and various applications are given.

The volume is well produced, but it deserves a more comprehensive index.

THERMODYNAMICS AND FLUIDS

Chemical Engineering Practice

Edited by Herbert W. Cremer and Trefor Davies. Vol. 4: Fluid State. Pp. vi+623+xix. (London: Butterworths Scientific Publications; New York: Academic Press, Inc., 1957.) 95*s*.; 13.30 dollars.

AN important section of the work of modern chemical engineers lies in the application of thermodynamics to problems of fluid systems. This volume, the fourth in the series, is devoted to the thermodynamic properties of physical systems and to the transport properties of fluids. The first section on thermodynamics has been written by Dr. R. Strickland Constable of the Chemical Engineering Department at the Imperial College of Science and Technology, and the second section on transport by Dr. Franklin of the Atomic Energy Authority and Mr. F. H. Cass of the University of Leeds. A final and useful chapter on the measurement of process variables is by Mr. A. Pollard and Mr. T. G. Carruthers of Leeds.

The first six chapters start with a short summary of the first and second laws of thermodynamics and continue with such topics as chemical potential as a criterion for equilibrium, general thermodynamic relationships, properties of single substances and of mixtures. In many ways this is a good section. We are given an excellent account of what is sometimes called chemical engineering thermodynamics of the fluid state, and the chapter on sum and difference methods is particularly useful in providing a basis to stagewise operations as indicated by liquid–

liquid extraction and so on. The main drawback to this section is that there are scarcely any examples and few good illustrations of the use of the thermodynamic functions. It is not sufficient to give thermodynamic functions, and relations between them, these concepts only become alive when it is clearly shown that they form useful tools. The Gibbs function and the Van Laar equations must be demonstrated to the practical engineer as of real use, and effective illustrations are vital.

The second section on the transport of fluids has more examples and clearly shows the great interest in boundary layer study, in the ideas of turbulence, and the flow and behaviour of compressible fluids. Here again practice is somehow missing, and the examples are rather academic.

This is a valuable book in that it provides the current ideas of the thermodynamic approach to the study of fluids; this has previously not been so clearly available in British texts. The volume suffers from the fact that one is not given the dynamic illustrations of the use of these tools, one does not sense the engineer at work at his practice, but rather that he is being presented with an academic text. How does one really design a large pipe-line, how does one measure the flow of high-pressure and high-temperature fluids, how do engineers really solve their problems ? Some actual examples, including failures that had to be corrected, would have been of great value to the practically minded reader.

J. M. Coulson

DRUGS AND THE BRAIN

Psychotropic Drugs

Proceedings of the International Symposium on Psychotropic Drugs, Milan, May 9–11, 1957. Edited by S. Garattini and V. Ghetti. Pp. xiv+606. (Amsterdam: Elsevier Publishing Company; London: Cleaver-Hume Press, Ltd., 1957.) 95*s*.

This expensive and extremely well-produced volume constitutes the proceedings of the International Symposium on Psychotropic Drugs held in Milan during May 9–11, 1957. It was printed in the Netherlands, and editors and printers deserve much praise for the speed with which the work was done and the excellence of the result; it cannot have been an easy task to assemble the final versions of the papers and to set the text in four different languages.

There are approximately 100 reports, roughly half of them quite short, the others of variable length. These reports are grouped into five sections, dealing with the biochemistry of normal and altered cerebral function, the behavioural effects of psychotropic drugs on animals, the electrophysiological basis of normal and altered cerebral function, the pharmacological aspects of centrally acting substances, and lastly clinical experiences. The drugs most widely used in the studies reported are the so-called tranquillizing drugs, in particular reserpine and chlorpromazine; hallucinogens are also well represented, and there are, of course, studies of the more traditional stimulant and depressant drugs as well.

The reader of this book will be impressed by a number of things. In the first place, there is a tremendous range in the simple technical competence of the research workers represented. This expresses itself in many different ways. To take but one example, we find that the psychologists tend to report means and variances for their experiments; the biochemists tend to state means only; the clinicians tend to rest content with a simple subjective estimate of trends. As the numbers used are normally quite small, and the variability in response to drugs is known to be tremendous, it is clear that for a number of reports no conclusions can be drawn from the figures given, because vital information is withheld and no tests of significance carried out. A second impression relates to the relative isolation of the various groups of workers. Any adequate theory of drug action must surely reconcile and synthesize the findings of biochemists, psychologists, pharmacologists, physiologists and other workers, yet each group tends to remain isolated from the others and ignorant of what is being done elsewhere. Perhaps the series of congresses, of which this was the first, may have the highly desirable effect of bringing these various workers closer together.

Some of the contributions are of such high quality or of such obvious interest that they stand out from the rest. Among them is a paper by A. Hoffer on the relation to mental disease of adrenochrome and adrenolutin; this investigation owes its interest to the similarity in the structure of these two oxidized derivatives of epinephrine to some active indolic hallucinogens. Another is a paper by N. E. Miller on objective techniques for studying motivational effects of drugs on animals; this combines in a remarkable manner a survey of available techniques with an exposition of the writer's own work; it is a gold-mine of information, as well as an admirable presentation of recent methodological advances in this field. B. Delisle Burns, in his paper on the electrophysiological basis of normal and psychotic function, discusses the bearing of his recent work on the physiology of learning, suggesting that traditional hypotheses of facilitation are erroneous. J. Olds and others contribute a chapter on the effects of tranquillizers on self-stimulation of the brain in which the remarkable discoveries of Olds on the rewarding properties of electrical stimulation of certain brain areas are used to discover the effects of a variety of drugs. His main discovery is the highly specific action of most drugs, depending on the precise placement of the electrodes. These are only some of the noteworthy contributions to this volume; others could have been mentioned as well. While having the inevitable defects of any symposium, this collection of papers has succeeded surprisingly well in presenting the reader with a worthwhile prospectus of current work.

H. J. Eysenck

MICROBES AND THE BIOCHEMIST

Annual Review of Microbiology

Vol. 11. Edited by Charles E. Clifton, in association with Sidney Raffel and Roger Y. Stanier. Pp. viii+536. (Palo Alto, Calif.: Annual Reviews, Inc., 1957.) 7 dollars.

The time is long past when biochemistry of micro-organisms could be covered adequately by a chapter in the "Annual Review of Biochemistry". To-day we have the converse situation, and the microbiology volume has an established place in the biochemist's library. Reviews such as Gale and McQuillen's on nitrogen metabolism might even prove heavy reading for many biochemists; though anyone wishing to understand some of the most exciting biochemical research of to-day will find this a most rewarding chapter. More than half the articles in this volume have a directly biochemical outlook, but in few can the reader escape far from fundamental biological observations which are unlikely to be interpreted at the molecular level for a very long time to come. This volume, indeed, provides a salutary warning against the facile assumption of biochemical omnipotence. This is apparent, for example, in Smith's essay on "Some Problems in Plant Virus Studies", which leaves the reader wondering whether viruses may not sometimes arise *de novo* in a healthy cell. Smith himself hastens to disclaim this heresy ; but at least this kind of patient observation and research provides a needed corrective to the over-enthusiastic bacteriophage specialist. It is, however, a matter of great practical importance to know whether the remarkable biochemical observations made on bacteriophages in recent years are valid for animal viruses and, in particular, human pathogens. Ross and Syverton, in their review on the culture of animal viruses in cell-suspensions, raise legitimate hopes that experimental study of their biochemical behaviour may be feasible.

We are led right back to the practical plane of field observations when we come to Miller and O'Brien's review on "Prediction of Plant Disease Epidemics", and the microbiologist finds himself allied with the meteorologist rather than the biochemist. This review will prove of great value to workers on this topic. Not only are scattered data collected from inaccessible journals, but a challenge is thrown out to the academic worker, too. Why should a parasitic fungus attack its host only when certain conditions of temperature and humidity are fulfilled ? One wonders if equally well-documented data are available for human diseases. But as "Annual Reviews" reveals new knowledge it also reminds us of territory where progress is less evident. One reads Thornton and Mieklejohn's contribution on "Soil Microbiology" with a sense of disappointment. In a world the human population of which is threatening to outgrow its food supplies, surely a greater effort could be directed to study of those micro-organisms which maintain the fertility of the soil—not only by circulating supplies of vital elements, but also through their influence on the very structure of the soil itself. Dental caries, too, is an expensive as well as a painful disorder, yet Hoffman's review on oral microbiology (though collecting much useful information for the bacteriologist's file) offers little hope for the victim of toothache.

One reads this volume with a sense of pleasure. It is all too easy for chapters to degenerate into undigested catalogues of references. This charge cannot be made here. Many of these articles are reviews in the best sense—presentations of the trend of current work by an acknowledged authority and in a form acceptable to those at the fringe as well as the centre of his chosen sphere. Many authors have wisely preferred to select topics which present interesting developments at the present time rather than to attempt to cover the literature comprehensively. But where the topic has been one of essentially specialist interest and it has been necessary to collect scattered references, this has been done faithfully. This volume has to meet a wide range of needs—from those of the academic biochemist to the clinical pathologist's or the agricultural field worker's. Editors and authors alike have served their readers well.

H. K. King

TAXONOMY OF VASCULAR PLANTS

Plant Classification

By Prof. Lyman Benson. Pp. xiv+688. (Boston, Mass.: D. C. Heath and Company; London: George G. Harrap and Co., Ltd., 1957.) 63*s*.

Prof. Benson, well known for his studies on *Ranunculus*, has produced a text-book dealing primarily with the classification of vascular plants but covering, at least in outline, a very considerably wider field.

The methods of collecting, preserving and describing plants, most of them at least 250 years old but still basic tools of taxonomy, are put into perspective alongside more recently developed parts of the field, such as ecology and genetics. This in itself should make the book of special value both to those whose interest is primarily in the classification of organisms and to the ecologist or geneticist.

The introductory chapters are concerned with the characteristics of flowering plants, the terms used in describing them, and the process of identification by means of keys. These, like the rest of the book, are abundantly illustrated by diagrams and line drawings, and the way to use a key is explained in detail by reference to species of *Ranunculus*. This part, most of which is in effect a detailed illustrated glossary, will be specially useful to the beginner.

The next 270 pages contain keys to the orders and families of flowering plants, brief descriptions of the families with a summary of their distribution, with special reference (naturally enough) to the United States, and sometimes a note on the geological history. This survey is on a world scale, though the descriptions appear usually to apply to the family as represented in the United States, a fact which, unfortunately, does not seem to be made clear. The result is that we are told, for example, that the Leguminosae are "Predominantly herbs but frequently shrubs and less commonly trees", a statement which is true for the United States, but quite untrue for the Leguminosae as a whole.

The chapter on the preparation and preservation of plant specimens deals with an aspect of the subject which is usually learnt by experience, but in which some instruction will save time and lead to better results.

The comprehensive section on the basis of classification consists of an outline, in 84 pages, of many topics which are of great importance in taxonomy but which have seldom, if ever, previously been included in text-books of this kind. There are chapters on evolution, examples being drawn from animals as well as plants, some fundamental problems of plant classification, historical development of classification systems and a system of classification designed for teaching.

The chapter on fundamental problems includes much valuable material, such as a brief consideration of hybrid swarms and convergent and divergent evolution, each topic being exemplified by reference to the flora of the United States. The final chapter of this section has a somewhat misleading title ; it consists of a discussion of the desirability and difficulty of producing a new classification, a summary of the evidence on which a phylogenetic one might be based, and a defence of the employment of a partially artificial system for teaching, as the

'Ariadne's thread' by means of which the student can be guided through the great mass of facts.

The book concludes with shorter sections, similar in general plan, on Gymnospermae and Pteridophyta, and a survey of the main vegetation types of the United States illustrated by excellent photographs and distribution maps.

Altogether this is a book admirable in conception but only partially suited to the student at an English university. There is the inevitable drawback that the examples quoted are familiar in the United States but only rarely so in Europe. A more fundamental difficulty is, however, that a good deal of space is occupied by material which is of General Certificate standard and that the rest of the subject-matter is too extensive for a general honours student but not carried to high enough levels, at least in the large and variable families, for the special honours student. Nevertheless there is no doubt that students of all grades, as well as their teachers, will gain much from browsing through this work. T. G. TUTIN

THE LIVING INVERTEBRATE

Spiders, Scorpions, Centipedes and Mites

The Ecology and Natural History of Woodlice, 'Myriapods' and Arachnids. By Dr. J. L. Cloudsley-Thompson. Pp. xiv+228+16 plates. (London and New York: Pergamon Press, 1958.) 50*s*. net.

THE author of this book is well known as a zoologist who has a predilection for seeking his living material in deserts and other uncomfortable places, where the frequent changes of temperature, illumination and humidity have pronounced effects on the lives of invertebrate animals, and he has supplemented this field-work with a long series of laboratory investigations on humidity preferences, water-content control and rhythmic behaviour. These researches have directed his attention to those arthropods which are not insects and which are very well suited to his purposes. The zoologist, the naturalist and the general reader are far less familiar with these animals—the woodlice, myriapods and arachnids—than with insects, and all will find a wealth of interesting matter in this book. By his introductory chapter, in which the first figure is a graph illustrating problems of desiccation, the author makes it plain that he does not intend to popularize or oversimplify his subject; and this attitude, none too common in books about animals, is consistently maintained and gives the book its outstanding characteristic. It is a feature that will commend itself to many zoologists, both readers and writers, and will even be a pleasant surprise to others.

The eleven chapters follow closely parallel lines. For each order or other grouping we are told of classification and distribution, general behaviour, food and enemies, reproductive habits and life-cycle. These topics are periodically lightened by the introduction of less-technical paragraphs. The author is always ready to remind us of myths or legends which have centred about these creatures and to share with us the smiles that they have sometimes provoked. With all his exact knowledge of recent work—and I have failed to find any topic of importance that has been omitted—he gives credit to the observers of past generations, who often hit upon facts or phenomena of significance and who, even if they did not fully understand them, have left us descriptions or illustrations which are still useful.

There is a section of excellent half-tone plates, but the supply of line figures is not over-generous. For example, there are references to the uses of pedipalpi and gnathobases where an uninformed reader might expect a drawing to make the text clearer.

None the less, this is a book of uncommon quality, and a first-rate example of zoological writing adapted to the widening reading public of the mid-twentieth century. Accurate without being abstruse, appreciative without being sentimental, clear in interpretation where interpretation is possible and as clearly conscious of difficulties where they exist, it should be welcomed by many. Perhaps it heralds a new movement in biology—a directing of popular attention to the unspectacular orders, from which so much is to be learnt. In this venture Dr. Cloudsley-Thompson must be congratulated; and a word of commendation is due to the publishers, who have shown faith and courage in producing so challenging a book. THEODORE SAVORY

OUR NATIVE MAMMALS

Field Guide to British Deer

Compiled and edited by F. J. Taylor Page. (Field Guide to British Mammals, No. 1.) Pp. 80. (Birmingham: Mammal Society of the British Isles, c/o the University, 1957.) 10*s*. 6*d*. net.

The Natural History of the Otter

By Marie N. Stephens. (A Report to the Otter Committee.) Pp. 88+4 plates. (London: Universities Federation for Animal Welfare, 1957.) 10*s*. 6*d*.

The Badger

By Ernest Neal. (Pelican Book No. A 410.) Pp. 176+30 plates. (Harmondsworth, Mddx.: Penguin Books, Ltd., 1958.) 3*s*. 6*d*.

THE first impression one gains from reading these three books is of the greatly increased interest now being taken in the natural history of our native mammals. The very formation of the Mammal Society of the British Isles a few years ago was evidence of that interest, and the publication of the first of its planned series of field guides, noted above, is a welcome addition to our literature on British deer. It deals chiefly with the five species most commonly found at large in Great Britain, but contains notes also on other species, such as the Chinese waterdeer, which may be seen in very limited areas.

This "Field Guide to British Deer" is a model of clarity and compactness. In its mere eighty pages it contains a wealth of observations, tables and sketches that one is unlikely to find in any other British book, all carefully compiled and set out to help one to ascertain which deer are present in any particular region, and to identify them when seen. Distribution, habitat, gait, tracks, droppings, seasonal behaviour, daily activities, voice, antlers, food and so on are all dealt with in a way that makes this attractive little book in green and gold a pleasure to consult. One looks forward eagerly to its promised successors in the same series.

So far as naturalists are concerned, the chief interest of "The Natural History of the Otter" will lie in Miss Stephens's intensive studies of this elusive animal in its natural haunts. The details she gives of its distribution and habits, its reproduction and breeding behaviour, its parasites and diseases, and above all its feeding habits, cover much fresh ground, and will throw new light on many an old belief regarding the otter's relationship to man and his needs.

These investigations were, in fact, carried out as a result of the report issued by the Home Office Committee on Cruelty to Wild Animals, which appeared in 1951. This Committee concluded that, since the hunting and trapping of otters undoubtedly involves suffering for these animals, a thorough investigation should be conducted into the natural history of the otter, and particularly into its feeding habits, so that an informed judgment could be arrived at concerning its alleged damage to fishing interests. It is unfortunate that, through lack of funds, the work had to be discontinued after about two years. It will be agreed, however, that an excellent start has been made, and one can only hope that such an interesting and useful project will be revived at no distant date.

The appearance of Ernest Neal's "The Badger" as a paperback will be welcomed by all who missed the original edition, which was published ten years ago as a New Naturalist Monograph. It is a magnificent example of well-directed endeavour, untiring patience and skilled photography, and now provides, as inexpensively as anyone could wish, a first-class introduction to the natural history of one of the most interesting of our lesser-known mammals.

RICHARD MORSE

AGE AND ABILITY

Ageing and Human Skill

A Report centred on work by the Nuffield Unit for Research into Problems of Ageing. By A. T. Welford. Pp. ix+300. (London: Oxford University Press, 1958. Published for the Trustees of the Nuffield Foundation.) 25*s.* net.

FOR ten years from 1946 until 1956 the Nuffield Foundation supported a Unit for Research into Problems of Ageing attached to the Cambridge University Psychological Laboratory. The present volume is the final and definitive account of the work accomplished by the Unit during this period, and in view of the high reputation which Mr. Welford and his team won for themselves it will be eagerly read not only by psychologists and gerontologists, but also by all who are interested both theoretically and practically in human performance. They will not be disappointed. In an eminently readable book Mr. Welford has made an outstanding contribution at once to the study of ageing and to general psychology.

The book is a successor to, and intended to supersede, Mr. Welford's earlier report "Skill and Age" (1951). It is just twice the length of the previous book; and although it contains again in new contexts most of the earlier material, it also contains much additional data and a re-working of the theoretical framework. It is richer in reflexions and suggestions for future work, refers to relevant research by other investigators, and includes a valuable new chapter on methodological problems in the study of ageing. On the other hand, the statistical appendix provided in the earlier volume has been omitted, and in an endeavour to simplify the statistical presentation rather too much vital information has been left out. For example, not until more than half-way through the book, and then only sporadically, are the numbers of experimental subjects given. As not all the experiments have been separately reported, it becomes impossible for the reader to carry out an independent evaluation of the results, and he has to accept the author's blanket statement that all the results are in fact significant at the 5 per cent level or better.

Broadly speaking the conclusions of "Skill and Age" are confirmed and amplified by "Ageing and Human Skill". Perhaps the most important additional finding from the practical point of view is the conclusion derived from the work of Kay and confirmed by other investigators that "changes of performance with age very commonly become disproportionately greater as the difficulty of the task rises". In an extremely interesting experiment on the training of women engaged on invisible mending in factories making woollen cloth, Belbin, reported here for the first time, has shown how a simplification in the way material is presented can profoundly affect the likelihood of success for trainees in middle age and beyond. This is one of a number of new industrial field studies reported in the book.

The re-working of the theoretical framework has led to the introduction of several new features. In "Skill and Age" skilled processes were analysed into receptor processes and effector processes. Between these is now included a third type of process, translation processes, which intervene between perception and action. Experimental examples are given illustrating the translation processes involved in transposing from one sensory mode to another and in making mirror reversals, but it cannot be said that Mr. Welford has made the scope and nature of these translation processes at all clear, nor has he made any attempt to explore their relationship to symbolic functioning generally. Theoretically their status remains vague. Perhaps more important is the new emphasis on the role of short-term memory backed up by a good deal of recent experimental work. Mr. Welford suggests that short-term retention is increasingly liable to interference by other activity as age advances, and that a good many of the diverse facts about learning and other changes of performance with age can be accounted for in this way. A possible explanation, he holds, may be contained in the fact that the number of active brain cells tends to diminish from young adulthood onwards, thus leading to a lessening of signal strengths, a lowered capacity for the establishment of reverberant circuits (upon which short-term retention probably depends), and a consequent increase of relative 'noise' level.

Inevitably in a book which covers a wide range of topics—movement, perception, problem solving, learning and memory, adaptability, etc.—there is some unevenness of treatment. The book is strong on the motor and perceptual aspects of skill. It is relatively thin and unsatisfying on problem solving and learning. The emotional, attitudinal and social factors which influence performance receive scarcely more than mention. But it would be unfair to hold these omissions against Mr. Welford, and only fair to point out that he is fully alive to them. With a small team of assistants, and in a limited period of time, he staked out his claim and has produced an impressive yield of results. Indeed, there is little doubt that the research reported in this book will be judged as one of the most significant pieces of psychological work produced in Great Britain since the Second World War.

L. S. HEARNSHAW

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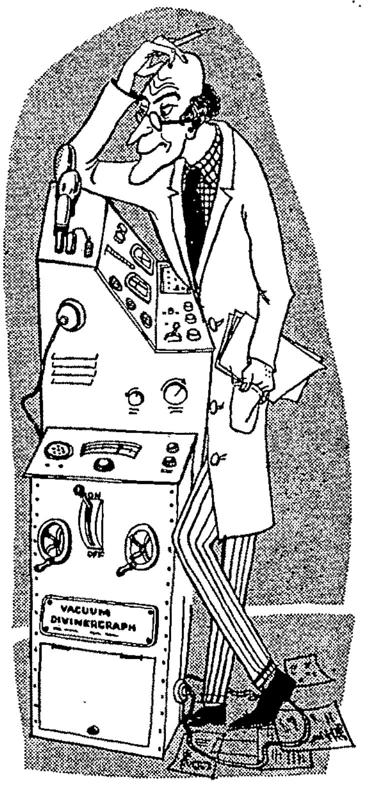

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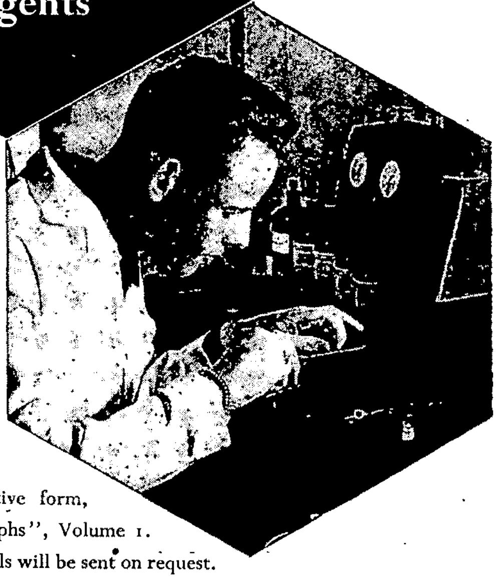

Soviet Research in Glass and Ceramics

Basic Science I. Pp. 1–259. Basic Science II. Pp. 260–497. 90 dollars. Glass, Glazes and Enamels. Pp. 197. 40 dollars. Cements, Limes and Plasters. Pp. 203. 35 dollars. Refractories. Pp. 70. 20 dollars. Miscellaneous. Pp. 31. 7.50 dollars. (New York: Consultants Bureau, Inc.)

THE Consultants Bureau, Inc., New York, have prepared translations of recent publications in Soviet research in glass and ceramics. These are available in five mimeograph collections. Full contents lists are available from Consultants Bureau, Inc., and individual reports can be purchased for 7.50 dollars each. It is useful to have in a form so easily available these translations of Russian publications. A very brief indication of the nature of the topics discussed may be given by referring to two major subjects on which several papers are included.

There are several papers on solid-state reactions by Ginstling and co-workers; these reactions are considered under the following headings: Chemical Reaction; Diffusion; Sublimation; Fusion; Crystallization.

Apen, in a lengthy series of papers, discusses the structure of silicate glasses in the light of the trend of behaviour of glasses as the composition is varied systematically. This information, together with the known co-ordination numbers of the various ions in crystals, is used to discuss the co-ordination of those ions in glasses.

There are many technological papers dealing with the reaction between sodium sulphate, carbon and silica, the thermal analysis of limestone, magnesite and dolomite in gas streams, the reaction of glasses with water and hydrofluoric acid, to mention only a few.

Of rather more general interest is a paper on X-ray transmitting glasses (Lindemann glass) with improved chemical durability. R. W. Douglas

Linear Equations

By P. M. Cohn. (Library of Mathematics.) Pp. viii+74. (London: Routledge and Kegan Paul, Ltd., 1958.) 5*s*. net.

Sequences and Series

By J. A. Green. (Library of Mathematics.) Pp. viii+56. (London: Routledge and Kegan Paul, Ltd., 1958.) 5*s*. net.

Differential Calculus

By P. J. Hilton. (Library of Mathematics.) Pp. vii+56. (London: Routledge and Kegan Paul, Ltd., 1958.) 5*s*. net.

Elementary Differential Equations and Operators

By G. E. H. Reuter. (Library of Mathematics.) Pp. viii+67. (London: Routledge and Kegan Paul, Ltd., 1958.) 5*s*. net.

THESE booklets, by members of the mathematics department of the University of Manchester, are intended for the student of science or engineering; they are in paper covers, but are well printed and reasonably cheap. The scope of Cohn's book is wider than the title, since linear equations are used to link together basic ideas about vectors, matrices and determinants. The discussion of m equations in n unknowns is carefully carried out, and a numerical method of solution is described.

Green's book treats sequences and their limits rather narrowly as a preliminary to the theory of series. The frightening professional apparatus of modulus signs and epsilons is discarded, and formal proofs are replaced by careful descriptions and apt numerical examples. The main convergence tests for series are given, including the integral test, and the properties of power series are given in some detail.

Hilton aims at comprehension rather than facile manipulation. The student must understand the meaning of the derivative; if correct proofs are too difficult, he must not be deceived by bogus arguments or false statements. Applications are to maxima and minima, and Taylor's theorem; the proof of the latter is a little too sophisticated for the science student, usually too ready to believe that mathematics is largely trickery.

Reuter is concerned with linear differential equations with constant coefficients. He first gives the familiar D method, and then an operational method which takes care of initial conditions; this is essentially Heaviside, and Reuter's treatment is on the lines of that given in the Cambridge tract by Sir Harold Jeffreys.

These are all useful little books, and topics suitable for similar treatment are doubtless under consideration by the editor of the series, Dr. Ledermann.

T. A. A. Broadbent

Advances in Biological and Medical Physics

Vol. 5. Edited by John H. Lawrence and Cornelius A. Tobias. Pp. x+488. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1957.) 12 dollars.

THE latest volume of this series contains an excellent selection of review articles taken from various parts of the subjects of medical and biological physics, together with a few excursions into subjects which can scarcely be regarded as 'physics', although no doubt they are of interest both as tools and as subjects for future biophysical researches. T. T. Puck's article on the genetics of somatic mammalian cells comes mainly within this category, although it includes some account of the action of high-energy radiation cells when grown under tissue culture conditions. The remaining articles cover a wide range of physical approaches to biological phenomena, for example, paramagnetic resonance, action spectroscopy, dielectric properties and even television techniques in biology and medicine.

Other articles deal with methods of low-level counting of radioactive isotopes (Anderson and Libby), which have assumed world-wide importance in view of the increasing contamination of the atmosphere, and the radioactivity of the human body (Spiers and Burch), an equally important subject at the present time.

W. F. Bale and J. L. Spar discuss the use of antibodies as carriers of radioactivity for therapy. This is an interesting idea, but I do not think the authors have quite established their case that (with isolated exceptions) the therapy of specific organs is a practical proposition at present. Still, it is of much interest to have a review of the experiments made in this direction.

A. Rose gives a discussion of some rather special features of human vision and R. E. Zirkle, in an excellent article, discusses the methods developed in his laboratory for the irradiation of small parts of cells and the effects observed so far.

J. A. V. Butler

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AN EPISODE IN THE RELATION OF METABOLISM TO CELL GROWTH AND MORPHOGENESIS

By Prof. F. C. STEWARD, F.R.S., and Dr. J. K. POLLARD
Botany Department, Cornell University, Ithaca, New York

PLANTS have the distinctive ability to synthesize protein from sugar and inorganic sources of nitrogen, and in this nitrogen-autotrophic behaviour they contrast sharply with the nitrogen-heterotrophic nutrition of animals. In fact, this ability of growing plants to carry out what may be called primary protein synthesis, that is, a net synthesis of protein from inorganic materials, represents one of the great outstanding biological problems. However, the association, if not the causal connexion, between protein synthesis and the growth of cells by division and by cell enlargement needs no re-emphasis here.

Plant proteins rarely contain hydroxy-L-proline in the quantities encountered in the collagen-like materials of the animal body. Indeed, hydroxyproline does not occur free in quantity in plants except in certain exceptional situations, and even then it may not be in the form (hydroxy-L-proline) that exists in collagen or in protein (for example, allo-hydroxyproline in *Santallum*[1]). Particular interest, therefore, is attached to some examples in plants in which ^{14}C-proline is directly and rapidly incorporated into a metabolically inactive plant protein (insoluble in alcohol, precipitable with trichloracetic acid), and then is progressively converted to bound hydroxy-L-proline.

The new observations to be described have developed out of an earlier investigation which was summarized in *Nature* and has been published more fully in the *Journal of Experimental Botany*[2]. The features of the new work which bear upon the subject of protein synthesis and which are of more general and current interest will now be summarized.

Hydroxyproline in Plant Protein

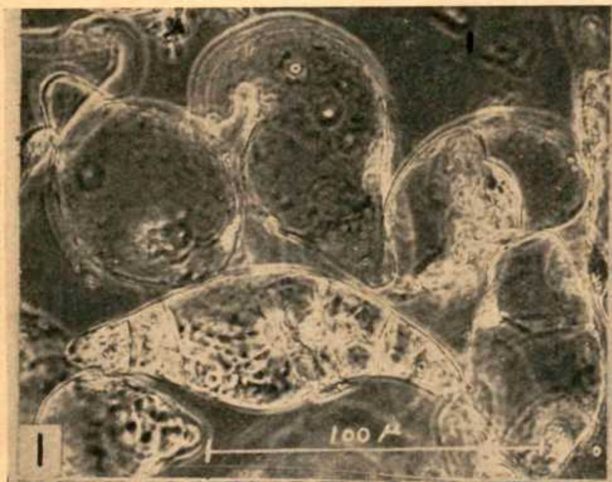
Hydroxy-L-proline is unusually conspicuous in the hydrolysates of the total protein of plant cells which are active in random proliferation. This has now been shown for carrot tissue cultures grown on a medium which contains coconut milk, for potato tissue cultures grown on a medium containing coconut milk and 2,4-D (2,4-dichlorophenoxyacetic acid) or some equivalent substance, for tumours which grow on *Nicotiana* hybrids, by virtue of their genetic constitution, and for the tumours which grow on *Kalanchöe* by the effect of the crown gall organism[3]. Hydroxy-L-proline occurs in substantial amounts in the protein hydrolysate of all these systems, even to some extent in the tissue which is formed by wound healing in the potato tuber, whereas it is either absent from, or present only in small amount in, the normal tissue. These observations should have meaning in the interpretation of the rapid proliferation which is characteristic of tumorous growth. It is also significant that tissue embarking upon this rapid proliferative growth can incorporate ^{14}C-proline readily into its protein and then convert it to hydroxy-L-proline.

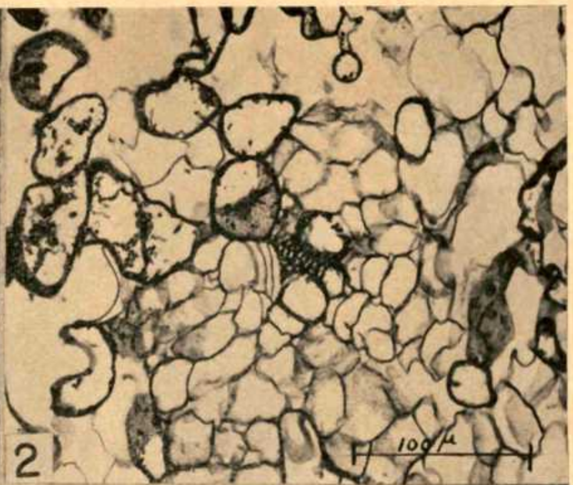
Growth of Disassociated Carrot Cells : Development from Carrot Cells to Carrot Plants

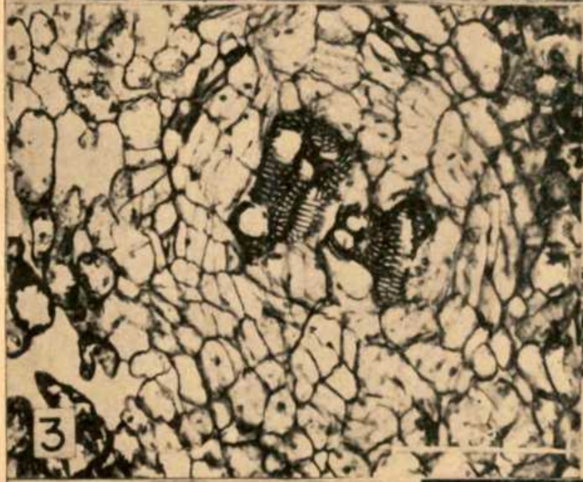
More recent evidence in this laboratory now shows that carrot phloem cells may be grown in the disassociated state in a culture medium which contains coconut milk (Fig. 1), and, after many transfers from culture to culture in this way, cells will re-form a loose proliferated mass (Figs. 2, 3 and 4), within which nodule-like centres of organized growth develop (Figs. 3 and 4). Cells in direct access to the coconut milk stimuli continue in random proliferation, but organized development only occurs after a more orderly type of growth develops. This orderly growth is stimulated by differentiating cells, around which a spherical sheath of cambial-like tissue grows in a response like wound-healing (Fig. 3). In this way a spherical nodule, or nest, of growing cells is produced within the loose tissue-cultured mass. The growing cells of this more orderly tissue now have more controlled, or limited, access to the coconut milk stimuli. It is in these situations that nests, or nodules, of growing cells have been shown to behave like the zygote, in the sense that they will form first roots (Fig. 4), then shoots (Fig. 6), and finally entire carrot plants (Figs. 5, 6 and 7) with secondarily thickened storage organs (Fig. 7). In other words, the journey from disassociated vegetative carrot cells to carrot plants has been achieved without benefit of sexual reproduction.

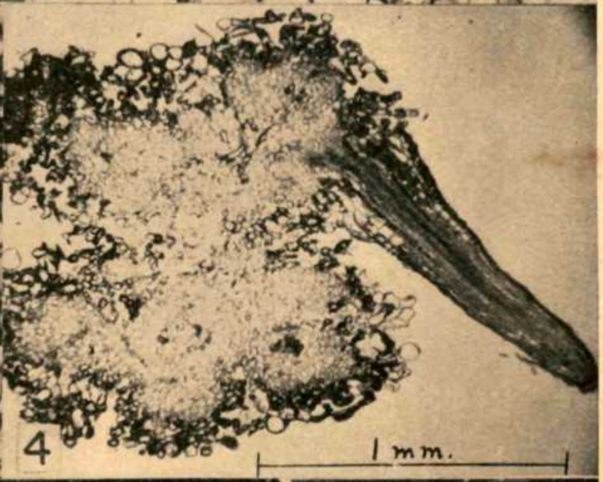
These facts of cell growth and morphogenesis are to be published more fully in the *American Journal of Botany* by one of us (F. C. S.) with M. Mapes, from whose photographs Figs. 1–7 are taken. They are mentioned here to emphasize the far-reaching conclusions that may well flow from the full understanding of all the events which first cause relatively mature cells, as they are removed from the plant body, to enter upon the rapidly proliferating state. After such cells have been grown in the disassociated state and then allowed to form colonies, they can respond to nutritional stimuli and form whole, and apparently normal, plants.

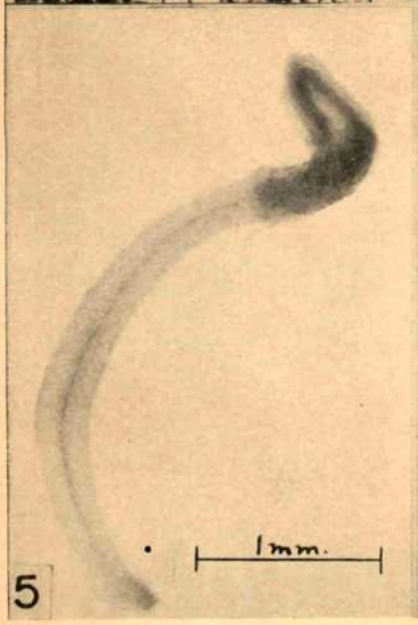
The distinctive protein metabolism of the cells which undergo the initial proliferative growth provides the background for any further changes which occur as such cells grow and form the pro-embryo-like structures. Since these events can occur, without the stimulus of sexual reproduction, when cells from mature tissue are subjected to a nutrient fluid which normally nourishes an immature embryo (namely, coconut milk or the liquid endosperm of the coconut), special interest is therefore attached to the metabolism of the cell and of the tissue cultures so stimulated. Indeed, these observations raise the question how far the events of embryology in the ovule are determined by nutrition and how far they presuppose the fertilization process. Plants in which

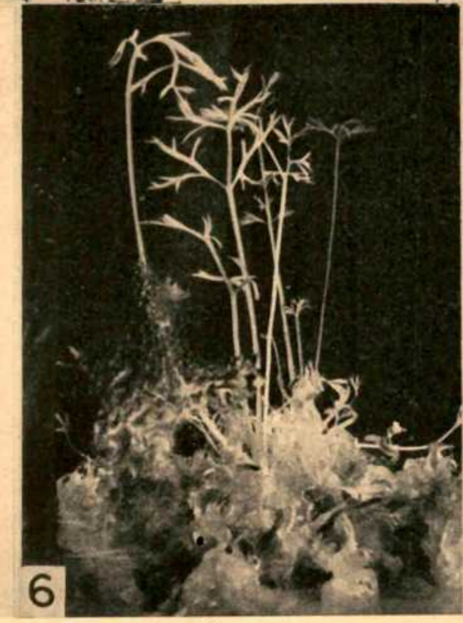


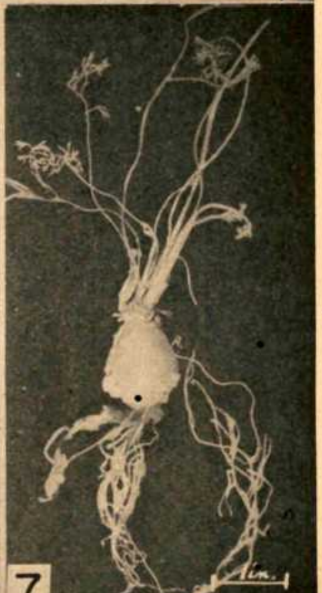












(1) A representative group of cells derived from the secondary phloem of carrot root, as these are grown in the freely suspended state in media containing coconut milk. These cells show recent divisions and a giant cell with internal divisions

(2) Loose mass formed by proliferation from cells freely suspended in liquid media; showing central cell which differentiates and adjacent cell divisions

(3) Nodule of growing cambial-like cells surrounding central nest of lignifying cells: from this structure roots and shoots develop

(4) Culture with various nodules or growing centres, from one of which a root has emerged; the roots were formed in liquid culture

(5) Young plantlet removed from loose cultured mass: shoots form only in stationary cultures on agar. This plantlet resembles an early stage of normal embryology

(6) Loose proliferated culture grown from disassociated, freely suspended, cells; roots and shoots developed as shown in (4) and (5)

(7) Complete carrot plant with shoot, root, and secondarily thickened storage organ: grown after cultures developed from freely suspended cells have been transferred to stationary semi-solid medium containing coconut milk. The storage root has proliferated where it was in contact with the medium

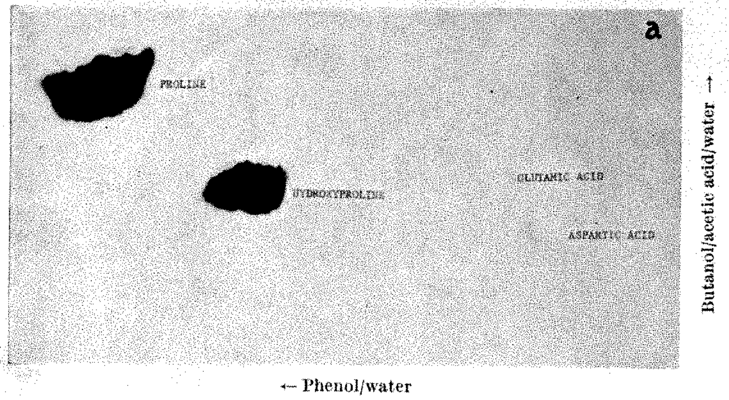


Fig. 8*a*. Radioautograph of chromatograms of hydrolysed protein fraction of growing carrot explants showing that ^{14}C-proline and ^{14}C-hydroxyproline in the protein are not metabolized

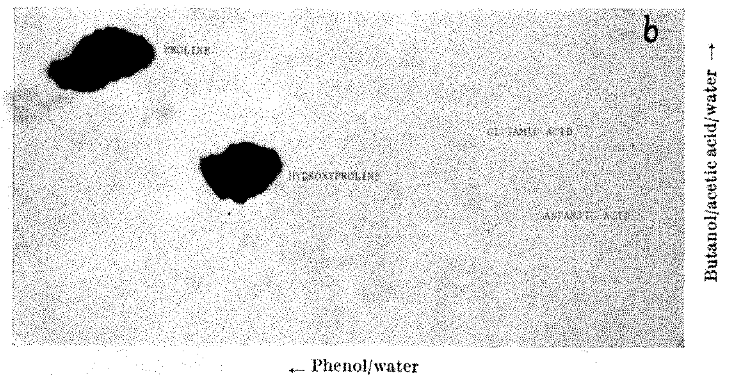


Fig. 8*b*. Tissue treated for three days with ^{14}C-proline and then grown for eight more days in ^{14}C-free media. (Average weight per explant, 72 mgm.)

apomictic development occurs may be instructive ones to investigate in this connexion.

Direct Incorporation of Endogenous Proline into Non-metabolized Protein

The role of proline in the protein synthesis of carrot tissue cultures was anticipated from work in which the protein was labelled with carbon-14 by supplying various substrates in the external medium[2]. The specific activity of the carbon in certain of the amino-acids (glutamic, aspartic, threonine) from the protein was higher than that of the corresponding free amino-acids in the cell, indicating that the carbon which became incorporated into these acids of the protein came more immediately from the carbon-14 substrate supplied than from the same acid as it occurred free in the cell. The coconut milk also increased the incorporation of carbon-14 into those amino-acids of the protein—over and above its effect upon synthesis—an effect which could only be explained by a stimulus of the coconut milk to protein turn-over, as well as its effect upon initial synthesis. The situation with respect to proline and hydroxyproline in the protein was, however, quite different from that which relates to glutamic and aspartic acids, threonine, etc. The specific activity of the proline and hydroxyproline in the protein was related closely to that of the carbon-14 in the proline free in the cell, and the incorporation of the labelled acid in the protein was stimulated by coconut milk in the same ratio that it stimulated total protein synthesis. This showed that carbon-14 could be directly incorporated into the protein from the free proline of the cell, and thenceforward it did not participate in further metabolic turn-over. This association (in growing carrot cells) of hydroxyproline with a protein moiety that does not participate in metabolic turn-over was, in this sense, reminiscent of the behaviour of collagen in the animal body.

Utilization of Exogenous ^{14}C-Proline by Carrot Explants

Against this background of knowledge, the following types of experiments have recently been performed and are to be described later in more detail[4].

Generally labelled ^{14}C-proline has been added to the external medium in which cultured carrot explants had already reached the exponential phase of their growth (that is, after several days of pre-growth in the medium). The ^{14}C-proline then rapidly enters the cell and within 15 min. radioactivity can be found in the fraction insoluble in alcohol. On hydrolysis of the fraction insoluble in alcohol, the radioactivity appears almost entirely in the form of proline and hydroxyproline, and after cultures have been in contact with the carbon-14 substrate for a day, the activity was almost evenly divided between the proline and the hydroxyproline of the protein.

Tissue which had thus incorporated ^{14}C-proline into its protein was allowed to metabolize and grow in a medium without the ^{14}C-proline for a further seven days, when it increased in fresh weight to more than 300 per cent of the initial weight; but, even so, the carbon-14 label remained exclusively in the proline and hydroxyproline of the protein (Fig. 8), and virtually none of the originally bound activity came off as carbon-14 dioxide. These facts clearly show that the protein moiety which incorporates carbon-14 directly from proline, and in which it is converted partially to hydroxyproline, certainly does not participate in metabolic turn-over. In this respect this metabolically inactive type of protein contrasts sharply with that which preferentially, but more slowly, incorporates carbon-14 from sugar into the combined glutamic and other protein amino-acids, for this protein does turn its carbon over, and some is respired away.

Conversion to Hydroxyproline

Time studies showed that the ratio of the carbon-14 in the combined proline to the carbon-14 in the combined hydroxyproline declined progressively with time—rapidly at first from a maximum of about 4 at 30 min., and thereafter slowly to a final value of 0·7 at the end of a week. In this respect the behaviour of the carrot cells is similar to that of animal cells, which synthesize collagen, for they also appear to incorporate proline and oxidize it in the protein *in situ*[5].

Time studies also showed that the direct incorporation of ^{14}C-proline into the protein of the rapidly growing cells was detectable 15 min. after its addition to the external solution, and synthesis proceeded linearly with time for some 24 hr. at least (Fig. 9).

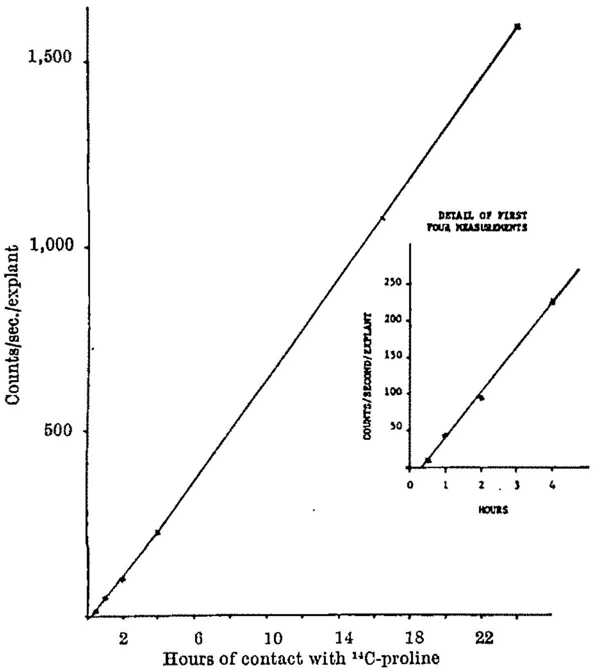


Fig. 9. Effect of time on the incorporation of carbon-14 from ^{14}C-proline into the alcohol-insoluble nitrogen fraction of carrot tissue cultures

Hydroxyproline and its Analogues as Proline Antagonists of Growth and Synthesis

Recognizing that a salient feature of the rapidly proliferating carrot cells is their formation of a protein moiety which contains hydroxyproline derived from proline, the use of exogenous hydroxyproline as a potential substrate for protein synthesis was tested. The addition of hydroxy-L-proline to the external culture solution at concentrations so low as 10 p.p.m. inhibited the growth induction, and therefore the total protein synthesis, otherwise stimulated by the coconut milk. This effect of hydroxyproline could be reversed by casein hydrolysate, but the only protein amino-acid which could do this successfully was proline itself[6]. Therefore, hydroxy-L-proline now emerges as a powerful antagonist of the growth induction due to coconut milk in this type of cell.

In co-operation with Dr. B. Witkop's laboratory in the National Institutes of Health at Bethesda, Maryland, about seventy-five compounds have now been tested for their ability to suppress growth and protein synthesis in ways that are reversible by proline[6]. The results are briefly as follows. The most effective proline antagonist is hydroxy-L-proline; hydroxy-L-proline compounds are more effective than the corresponding hydroxy-D-compounds; substitution either on the oxygen or the nitrogen of the hydroxy-L-proline molecule reduces the inhibitory effect, and especially so when the substitution is on the nitrogen atom.

By the use of biosynthetic ^{14}C-hydroxyproline it was shown, unequivocally, that this acid freely entered the growing cells and was detectable as such in the alcohol-soluble extract. Any minute amount of radioactivity (3 per cent) which slowly entered the protein from ^{14}C-hydroxyproline is presumed to do so by prior conversion to proline, entry into the protein as such, and then reconversion to hydroxyproline in the protein, since both appeared in the protein in a ratio consistent with that observed when ^{14}C-proline is supplied[4].

Proline and Hydroxyproline in the Induction of Growth by Coconut Milk

Two types of response in the plant tissue cultures need to be distinguished. The first concerns the transition of the resting tissue of the carrot root into the rapidly growing state, and the second concerns the continuance of that growth once it is well established.

The first of these, namely, the growth induction phenomenon, is known to be brought about by the stimulus of the coconut milk or other fluids, and it requires a finite time to take effect; during this time, cells first enlarge more than they divide, and a phase of rapid cell division follows[7].

Other work in this laboratory has shown that during this initial induction phase the response of the tissue is sensitive to carbon monoxide and to cyanide and to relatively low dosages of radiation. Eventually, after growth has been induced, the tissue becomes less sensitive to all these adverse stimuli.

The centres at which the growth factors act to induce growth must therefore be accessible to all these antagonistic effects, and it is now seen that exogenous hydroxyproline must be included among the effects that are inimical to the cell-division growth factors provided by the coconut milk. Because the adverse effect of hydroxyproline is prevented by proline, which also enters the protein, this implies that direct incorporation of endogenous proline and its conversion to hydroxyproline in the protein synthesized is a very real part of this growth-induction response. However, after the growth induction has taken place and the tissue is well embarked upon its proliferative growth, finite amounts of proline may be incorporated with but little effect of added hydroxyproline—at least during short periods of exposure to ^{14}C-proline. Thus, again it is necessary to distinguish effects which induce growth at the outset from those that are compatible with its continuation.

Significance of the Non-labile Protein Moiety

These results parallel events that are now attracting attention in the animal body. The stimulus to collagen synthesis that often accompanies wound healing has been noted, and collagen synthesis is a feature also of some diseases, for example, arthritis[8].

It is tempting to see some structural role in the dividing plant cells for this non-labile protein, which resembles collagen in its composition but not in its solubility. The presence of pronounced cytoplasmic strands and active streaming in the free cells which grow on coconut milk media (Fig. 1) offers a suggestive location for such an elastic protein moiety. Labelling experiments are contemplated in an attempt to localize this protein in these cells, which contain this unusual plant protein in quite large amounts.

Protein Turn-over: Labile and Inert Protein Moieties

A suggestive feature of the coconut milk stimulus to the growth of plant cells is a markedly increased rate of metabolic turn-over, which involves a part only of the protein[2]; this is linked also with a similar stimulus to respiration, as shown by the evolution of carbon-14 dioxide. The carbon of the respired carbon dioxide which is linked to protein turn-over moved perforce through the sequence of protein synthesis and breakdown. But the protein of these cells also includes a part which is remarkably stable and free from such turn-over, and this part includes the combined hydroxyproline. The latter part of the protein, in fact, resembles a virus protein in that it is, metabolically, at a 'point of no return'.

Since the work on plants links the inception of this special kind of protein metabolism to the induction of growth in cells which proliferate, when attached to an explant, the interest of these phenomena in relation to tumorous growth seems clear. However, the additional fact that similar cells growing free may, in the presence of the natural nutrients for an immature embryo, develop into proembryo-like structures from which entire plantlets can be grown, sets this type of protein metabolism in a milieu from which fascinating morphogenetic events emerge.

From mature carrot phloem, to growing tissue cultures, to disassociated cells, to centres of growth out of which roots emerge, then shoots, is a remarkable morphogenetic sequence, and the significant feature is that the nutritional and special stimuli are furnished by the nutrient fluids that normally nourish immature embryos. One distinctive biochemical feature of this system, at the outset of its response, is the inception in the carrot cells of a characteristic type of protein metabolism leading to the formation of a protein which contains hydroxyproline formed *in situ* in the protein from proline.

This work forms part of a programme of research which has been supported by grants from the National Cancer Institute, National Institutes of Health, United States Department of Health, Education and Welfare, Bethesda, Maryland. Assistance with the work on aseptic culture of plant tissues was made possible by these grants and was given successively by Miss K. Mears and Mrs. M. Mapes; this is gratefully acknowledged.

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GEOLOGY AND OIL

THE British Association for the Advancement of Science, Section C (Geology), held a symposium on "Geology and Oil" at the Royal College of Science and Technology in Glasgow on August 28. Sir Alexander Fleck, president of the British Association, presided over a luncheon given by the combined oil companies and representative local industries. Prof. L. R. Wager, president of Section C, took the chair for the session.

Mr. F. E. Wellings, chief geologist of the Iraq Petroleum Company, summarized the contribution of geology to the oil industry. Col. Drake's first well in 1859 was located on oil seeps. Although geologists connected the early Appalachian oilfields with anticlines, geological advice was at first resented by oil men ('wildcatters'). However, by the first decade of this century, oil companies were employing survey and academic geologists, and the United States Geological Survey began publication of studies of the geology of oil and gas. By the First World War, oil companies had permanent geological departments.

Surface mapping for anticlines, examination of drill cuttings and prediction of subsurface structure were the first geological techniques to be used. Oil is common in sedimentary rocks, but commercial oil occurs in underground traps where porous rocks, such as sandstone or limestone, are confined by impermeable rocks. Oil flows by artesian pressure of brine below it or by the expansion of natural gas in the reservoir. All the major oilfields of the Middle East are anticlines, found by geological mapping or geophysics. Systematic use of Foraminifera, microfacies and detrital minerals dates from the early 1920's. Aerial photography for mapping and photogeology, gravity survey by torsion balance and subsurface mapping by refraction seismic work began about the same time. Gravity and seismic methods discovered their first oilfields in 1924. Schlumberger electrical well logging of boreholes began in 1928. The replacement of the torsion balance by the gravimeter, refraction by reflexion seismography, improved coring and logging techniques and innovations such as ecology and gamma-ray logging make oil geology a dynamic science. Improved interpretation and presentation of results is important and a new hybrid personality, call him a 'geophysical geologist' or 'geological geophysicist', is best qualified for future oil finding. Repressuring by gas or water injection, to give secondary recovery of oil, demands more geological knowledge and engineering skill, but costs rise while the value of the oil does not. Geological survey is cheap, seismic prospecting is 10–15 times as expensive, whereas drilling costs twice that. Increased geological efficiency leading to drilling fewer dry holes therefore offers big savings. There is as yet no direct physical way of detecting actual accumulations of oil. "Oil is where you find it" and the only final test is the drill. Great technical effort will be required from geologists to meet the expected doubling of demand for oil in the next twenty years. There must, too, be the urge. Because the rewards of success are so great, the oil geologist must temper scientific caution with optimism.

Dr. A. H. Smout of the Iraq Petroleum Company explained the theory and practice of microfacies work. The method was described by H. B. Milner in 1926, but the term was introduced by Prof. J. Cuvillier in 1951 in presenting his beautiful photographs of thin sections of limestones from Aquitaine. It implies the sum of the lithological, mineralogical, textural and fossil characters of a sedimentary rock as seen in thin section. Although there is a background of detailed investigations by any means deemed suitable, routine microfacies work relies on simple inspection, usually at a magnification about × 25, and without petrological microscope equipment. Most common sedimentary minerals and many microfossils, particularly Foraminifera, can be identified and various details otherwise invisible give information. Simple comparison of appearance is often sufficient for local correlation or broad stratigraphical use. Textures, however, reveal index species and facies indications. The original sedimentary grains reveal their origin and much about their transport and deposition. For example, a freshwater limestone differs from a marine one, and depth zonation of paleogeographical facies is often found. Wind-blown sand grains differ obviously from water-worn ones. Secondary textures arise in diagenesis, partly or wholly altering the original texture, such as the recrystallization of aragonite to calcite. Metasomatism, altering calcite to dolomite, iron ore, flint, etc., involves bulk replacements of elements in the solid rock, but often the original characters can still be stated. Low-grade metamorphism may be seen. Strain texture in the form of calcite veins, stylolitic sutures or cleavage of minerals may be found.

The industrial value of microfacies work depends on its rapid routine empirical use; a determination being possible within one hour of sampling if necessary. It offers direct comparison between outcrop samples, cores and well cuttings, often as small as a pea. Its value is greatly increased by the additional information on facies variation. The amateur geologist will find the method possible with the minimum of equipment, but like the expert must persevere until he knows the appearances of all the local hard rocks. Limestones are easy to section and give the greatest variety of geologically significant variations.

The close relationship of geology and geophysics in oil exploration was emphasized again by Mr. D. R. Brown, chief geophysicist of Iraq Petroleum Company. Physical measurements permit an extrapolation of the geological observations at the surface or in wells, but lead to a final interpretation in geological terms which can only be developed by close collaboration.

Since the War the Iraq Petroleum Company group of companies have observed nearly 250,000 stations in gravity reconnaissance and covered about 15,000 miles of more precise seismic traverse. Normal development from a tenuous gravity lead and a semi-detailed seismic survey was illustrated by the results discovering the prolific oil-fields of Zubair and Rumaila in the Basrah area of Iraq. Additional knowledge of the distribution of seismic velocities in this area is still being built up and is aiding the final appraisal of the sub-surface structures needed for their efficient development.

Improved techniques and instrumentation are now being applied to the detailed seismic work. Areas of loose sands or cavernous limestones, previously unworkable, now yield readable reflexions to multiple patterns of shot-holes and geophones which direct and concentrate the ground energy. Magnetic tape recording allows the analysis of the received energy and accentuation of the particular characteristics desired. The recognition and elimination of disturbing reverberations give a truer knowledge of the velocity distribution in depth.

Electronic or photographic reproduction of a series of records with appropriate corrections simplifies the calculations and interpretation from the resultant cross-sections.

The logistics of maintaining the large amount of equipment present major problems in the more remote desert areas, particularly if continuous working throughout the summer months is desired. Recently, a survey in the marsh areas north of Basrah has required the development of a special floating camp and working equipment of a type not usually associated with Middle East regions.

Dr. J. Birks of the British Petroleum Company briefly described the logs which are commonly used in the course of drilling oil wells. These are drilling, geological, drilling mud, geochemical and core analysis logs, but the term 'well logging' is now generally applied to electrical and radioactive measurements of the rocks and their fluid contents.

Electrical and radioactive well logging are comparatively recent innovations, but they have become essential exploration tools. Four main groups of instruments are now used. Electrical sondes measure the depth, diameter and inclination of the borehole; electro-mechanical sondes measure temperatures and pressures and give the flow-rate of fluids produced from or injected into the hole; electrical sondes measure the resistance of the rocks, their water, oil or gas contents, the salinity of the water and, in modified form, give the angle and direction of dip of the strata; radioactive sondes measure the natural gamma-radioactivity of the rocks and the induced radioactivity (the neutron log).

A complete section of the borehole can be logged and the results presented on a small number of charts. A complete pattern of the borehole is available to the geologist, who can compare the lithology of the drill cuttings with the log data and define the sand/shale sequences, coal seams, limestones, etc. Detailed interpretation gives porosities, water content and salinity, and zones of oil and gas accumulation. The only important rock property not yet measurable by logging is permeability, that is, its ability to produce fluid into the borehole. This must be measured by production test, but the zones to be so tested are decided from the electrical and radioactive logs.

Recent developments are the presentation of logs in variable density form and the use of television cameras in boreholes.

Mr. N. L. Falcon, chief geologist of the British Petroleum Company, concluded the symposium with an address on the contribution of oil exploration to the advancement of geological science. The word geology was used in the widest sense to include all knowledge having a bearing on the constitution of the Earth's crust. Previous speakers had dealt with the assistance which geology and allied sciences gave to oil exploration and the final talk had as its theme the manner in which oil exploration repays the debt. Oil exploration has added an enormous amount of world-wide factual data to the general fund of geological knowledge. Geological research begins with reconnaissance but rapidly tends towards the study of available evidence in greater and greater detail. The great contribution the international oil industry makes to geology is to extend the reconnaissance phase of research into inaccessible places all over the world, below the surface as well as on it.

Large areas of the Earth would not yet have been mapped had it not been for oil exploration. The information from boreholes represents the examination of 50,000 miles of continuous vertical section each year, for in the United States alone 45,000 miles of hole are drilled yearly. The wealth of information so obtained has led to development of isopachyte and facies maps and the study of deltaic deposits. It has also resulted in a greatly increased knowledge of rock deformation before elevation and erosion.

Other important contributions to geological science by oil exploration were discussed, for example, in the field of micropalaeontology particularly with reference to Foraminifera, in photogeology where present techniques have to a great extent been developed within the oil industry, in electrical logging devices and in the development of geophysical tools for sub-surface exploration.

Mr. Falcon concluded by stating that the term 'oil geology' tends to obscure the fact that here is one branch of geology which is devoted to accumulating knowledge about the Earth's crust and that the geologists serving the industry have exceptional opportunities for doing so. Much information has been released; much more could not be released for various reasons not the least of which is the effort required to collate and publish the wealth of factual data available. That already published presented an embarrassing bulk.

An exhibition of oil geology and geophysics was open for the whole week of the British Association meeting. This was arranged on behalf of the British Association by the British Petroleum Company, Ltd., with assistance and contributions from Burmah Oil Company, Ltd., Iraq Petroleum Company, Ltd., Kuwait Oil Company, Ltd., and Shell Petroleum Company, Ltd. Actual samples, instruments and primary records, photographs of geological operations and final interpretations of geological results in the form of geological and geophysical maps, and of models of subsurface geological structure, were on display. The exhibition aroused considerable interest, particularly among the many members who had connexions with other industrial applications of geology. Mr. V. W. Baker, of the British Petroleum Company, Ltd., displayed the exhibition to the maximum advantage in the ideal surroundings of the laboratories of the Department of Mining of the Royal College of Science and Technology generously made available by Prof. G. Hibberd.

A. H. SMOUT

DEPOSITION OF STRONTIUM-90 AND ITS CONTENT IN VEGETATION AND IN HUMAN DIET IN THE UNITED KINGDOM

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Introduction

If strontium-90 is deposited either at a relatively steady rate as in world-wide fall-out or in a sudden deposition of short duration, as might occur after a reactor accident, its long-term consequences can be assessed only if the mechanisms whereby it enters plants, and hence reaches human food, are understood. On the simplest analysis the strontium-90 in plants can be divided into two components, namely, that which lodges on the leaves, stems or surface roots and is absorbed by them, and that which is absorbed after incorporation into the soil. If the deposition is continuous, the former component will depend on the quantity deposited during the life of the plant, and it is therefore a function of the rate of fall-out; the latter component will depend on the cumulative deposition. It is thus necessary to solve the equation:

$$C = aD_p + bD_T \qquad (1)$$

when C is the strontium-90 content of the plant; D_p and D_T are the deposition during the life of the plant and the cumulative deposition respectively, and a and b are proportionality functions. For any one species in a given environment a should be relatively constant with time; as will be shown later, however, b may change progressively.

If strontium-90 is released for a short period only, equation 1 should be applicable to plants growing at that time. Afterwards, however, the relevant equation will be:

$$C = bD_T \qquad (2)$$

The same equations can be applied to agricultural products, such as milk, which contain strontium-90 derived from vegetation.

An attempt is made here to solve these equations in the light of the results both of surveys of world-wide fall-out[1,2] and field experiments in which radioactive strontium has been applied to the surface of land which has been afterwards cultivated as nearly as possible by normal agricultural methods[3,4]. The present conclusions are tentative only; they appear, however, to provide the best fit to the data at present available.

General Aspects of the Behaviour of Strontium-90 in Plants and Soils

The movement of strontium-90 through food chains is similar to that of calcium but not identical with it, and the hazard to the human population from the ingestion of strontium-90 depends largely on the quantity of calcium with which it is accompanied, as the two ions are laid down side by side in bone. Thus the comparison of their behaviour is of particular importance. Strontium, like calcium, is relatively immobile once it has reached the leaves of plants, and for practical purposes its subsequent transfer to other tissues can be ignored. Some discrimination between the two ions occurs within plants, and the ratio of strontium to calcium in roots normally exceeds that in shoots. The overall effect of this discrimination is, however, small, and water-culture studies indicate that in a practical assessment the ratio of strontium-90 to calcium in plant shoots can be regarded as similar to that in the outer medium; no large intraspecific differences in discrimination between strontium and calcium have been established[5].

Water culture studies show that the rate of absorption of strontium is closely dependent on the external concentration of strontium plus calcium[6,7]. This simple relationship has, however, not been borne out in a number of investigations in which plants have been grown in soil[8,9]. This appears to be because conventional methods for soil extraction are inadequate to assess the availability to plants of strontium-90 relative to soil calcium; there is evidence that strontium-90 and calcium are absorbed in proportion to their concentrations in the equilibrium soil solution, and methods for measuring this ratio are under investigation[10]. In subsequent discussion the term 'ratio of strontium-90 to calcium' in soil is used with respect only to the fractions of the two ions which are of comparable availability to plants.

The study of the absorption of strontium-90 from world-wide fall-out under field conditions is complicated by its non-uniform distribution in the soil profile. More than 70 per cent of the strontium-90 as yet deposited by world-wide fall-out is in the upper 5 cm. of undisturbed soil[11]; numerous laboratory experiments have confirmed its slow downward movement[12]. Thus the ratio of strontium-90 to calcium varies greatly through the soil horizons from which plants absorb ions. With the passage of time, especially if ground is cultivated, the distribution of strontium-90 will become more uniform, so that even if no further strontium-90 enters, the ratio of strontium-90 to calcium in the rooting zone may change. For example, if plants absorb the major part of their nutrients from the upper soil layers the ratio of strontium-90 to calcium accessible to them should decrease steadily with time. The extent of this effect is indicated by field experiments in which rye-grass was grown in soil to which a constant quantity of strontium-89 was applied either as a surface dressing immediately after the sowing of the seeds or alternatively was cultivated into the soil to different depths[4]. Ploughing to 12 in. (Table 1) caused the ratio of strontium-89 to calcium in plants to be on the average only 30 per cent of that resulting from a surface application. More deeply rooted crops, for example cereals, were less affected by the depth of placement of strontium-89. There is no evidence that strontium is fixed in soils in a manner comparable with that which occurs with potassium or phosphate[12], but it is clear from Table 1 that the progressive mixing of strontium-90 in the soil, which will occur especially rapidly if land is cultivated, may result in its accessibility to plants decreasing steadily relative to that of calcium. Thus over long periods the function b in equation 1 cannot be regarded as a constant.

Extent of Absorption of Strontium-90 from Soils by Plants under Field Conditions

As world-wide fall-out continues, the quantity of strontium-90 in the soil will become progressively greater relative to that which is deposited annually. Thus the absorption of strontium-90 from the soil should contribute an increasing fraction of the total plant content. The prediction of long-term trends is therefore possible only if the extent of absorption of strontium-90 from soil is known. Attempts have been made to study this question by applying equations similar to equation 1 to the results of surveys of world-wide fall-out[13]. This approach is considered unsatisfactory since it implies that the function b in equation 1 is a constant. Furthermore, the method is unavoidably imprecise when the component of plant content which is dependent on the rate of fall-out (aD_p) is relatively large, since the soil component (bD_T) is then a small difference between two large quantities. The results of field experiments therefore appear to provide a more satisfactory basis for assessment.

Table 1. RESULTS OF FIELD EXPERIMENTS IN WHICH STRONTIUM-89 WAS APPLIED TO THE SURFACE OF THE GROUND AND CULTIVATED BY DIFFERENT METHODS BEFORE THE GROWTH OF RYE-GRASS (MILBOURN *et al.*; ref. 4)

Depth of cultivation after contamination	Ratio of strontium-89 to calcium in plant shoots (μc. Sr-89/gm. Ca)				
	Experiment No.				
	3	4	5	6	Mean
A nil	1·53	4·26	5·76	5·81	4·34
B 4 in.	1·03	2·03	2·44	3·49	2·25
C 7 in.	0·68	1·33	1·41	3·37	1·70
D 12 in.	0·23	0·99	1·34	2·84	1·35
Statistical significance (*P*):					
A *v*. Rest (per cent)	0·1	0·1	0·1	5	
B *v*. *D* (per cent)	0·1	5	1	1	

Results expressed on basis of 1,000 μc. strontium-90 applied per m. ground surface.

Table 2. ASSESSMENT OF MEAN STRONTIUM-90/CALCIUM RATIOS FOR CROPS IN BRITAIN DUE TO ABSORPTION FROM SOIL CONTAINING 1,000 $\mu\mu$c. Sr-90/m.^{2}

Survey of cultivated agricultural soils in Britain		Results for experiments (ref. 4) adjusted to bases of 1,000 $\mu\mu$c. Sr-89 added per m.^{2}			Contribution to country-wide mean $\mu\mu$c. Sr-90/gm. Ca (6)
Extractable soil Ca > (1)	Fraction of total area (2)	Experiment No. (3)	Extractable soil Ca (4)	Mean $\mu\mu$c. Sr-89/gm. Ca (5)	
15	0·54	1 2	23·0 22·6	0·67 0·70 } 0·69	0·37
10–15	0·17	3	14·1	0·79	0·14
5–10	0·24	4 5	8·3 7·2	1·20 2·05 } 1·63	0·40
< 5	0·04	6	2·2	4·52	0·20
			Country-wide mean : 1·1		

Notes: Columns 1 and 4—values were determined by extraction of soil with *N* ammonium acetate and are expressed as milli-equivalents Ca/100 gm. soil. Column 2—shows results of a survey of cultivated agricultural soils (ref. 14). Column 6—calculated by multiplying column 5 by column 2. By summing the entries for the four soil calcium classes the country-wide mean, weighted for the areas of different soil types, is obtained.

For this purpose the results of six experiments on contrasting soil types have been used[4]. In each, three test crops were grown (a grass/clover mixture, cereals and either a 'root' or a forage crop) after strontium-89 had been incorporated into the soil by the three cultivation procedures indicated in Table 1. The results were corrected for radioactive decay so that the fate of strontium-90 can be inferred. In Table 2 (cols. 3–5) the mean result for all cultivation treatments and all crops in each experiment are expressed as ratios of strontium-89 to calcium, and not as percentages of strontium-89 absorbed, since the latter will vary more with crop yield. The ratios of strontium-89 to calcium in plants were highest in soils of low calcium content. However, the observed differences should not be taken as a basis for generalization with regard to the effect of soil calcium, since it appears[4] that factors other than soil calcium were important in determining the strontium-89 content of plants grown in the soil of lowest calcium content. None the less, variations in soil calcium must be taken into account in the construction of a country-wide mean. To this end the results of the experiments have been weighted in accordance with the fraction of the total cultivated land in England and Wales which is of similar calcium status[14]. Hill grazing has been excluded as it is a minor source of dietary calcium. On this basis the country-wide mean value is 1·1 $\mu\mu$c. strontium-90/gm. calcium in plants when the deposition is 1,000 $\mu\mu$c. strontium-90 per m.^{2} (that is, 1 mc./km.^{2}).

Although this calculation appears to be less questionable than the use of the result of surveys of world-wide fall-out, the present figures must be treated with caution. The experiments span the range of calcium content in British soils but they cannot be regarded as truly representative; no account has been taken of factors other than soil calcium which affect the absorption of radioactive

Table 3. COMPARISON OF OBSERVED LEVELS OF STRONTIUM-90 IN MILK AND VEGETABLES IN THE UNITED KINGDOM WITH LEVELS EXPECTED TO RESULT FROM ABSORPTION FROM THE SOIL

Material (1)	Collection site and date (2)	Cumulative deposition at mid-season mc./km.^{2} (3)	$\mu\mu$c. Sr-90/gm. Ca		
			Observed (4)	Calculated (*e*) (5)	Ratio: $\frac{\text{observed}}{\text{calculated}}$ (6)
Milk	Frome, Somerset 1955	3·6 (*a*)	4·1 (*c*)	0·28 (*f*)	15
	1956	5·4 (*a*)	4·4 (*c*)	0·42 (*f*)	10
	1957	8·0 (*a*)	5·1 (*d*)	0·63 (*f*)	8
Lowland pasture	Chilton, Berks 1956	4·3 (*a*)	33 (*c*)	3·0 (*g*)	11
	Mean for six sites 1956	5·0 (*b*)	45 (*c*)	5·5	8
Annual vegetables (edible tissues)					
Potato	Mean for four localities 1957	7·7 (*b*)	23 (*d*)	8·5	2·7
Carrots		7·7 (*b*)	11 (*d*)	8·5	1·3
Cabbage		7·7 (*b*)	11 (*d*)	8·5	1·3
Lettuce		7·7 (*b*)	23 (*d*)	8·5	2·7
Peas and beans		7·7 (*b*)	8 (*d*)	8·5	0·9

(*a*) From Stewart *et al.* (ref. 15) adjusted on basis of local rainfall.
(*b*) From Stewart *et al.* (ref. 15), assuming mean rainfall of 75 cm. per annum.
(*c*) Bryant *et al.* (ref. 1).
(*d*) Bryant *et al.* (ref. 2).
(*e*) Based on calculation that 1,000 $\mu\mu$c. Sr-90/m.^{3} will lead to 1·1 $\mu\mu$c. Sr-90/gm. Ca in plants (see Table 2).
(*f*) Adjusted from mean values calculated in Table 2 on basis of (1) mean level of labile calcium in cultivated soils in Somerset ($<$ 10 m.equiv./100 gm.: 1 per cent; 10–15 m.equiv.: 1 per cent; $>$ 15 m.equiv.: 98 per cent (ref. 14)); (2) Sr-90/Ca ratio in milk assumed to be 0·14 of that in diet (Comar *et al.*, ref. 5); and (3) 20 per cent of dietary Ca of cattle is uncontaminated.
(*g*) Adjusted for mean value calculated in Table 2 for soil containing $>$ 15 m.equiv. labile Ca/100 gm.

strontium. Moreover, the experiments have been carried out for only one season and since the strontium-90 has not been incorporated as fully in the soil profile as would be the case under continuous cultivation (on the average of all treatments 50 per cent remained in the top 4 in.) it is probable that the situation which would occur after long periods of cultivation has been overestimated.

World-wide Fall-out: the Present Mechanism of Entry of Strontium-90 into Vegetation

Estimates of cumulative deposition of strontium-90 in the United Kingdom have been made[15] and ratios of strontium-90 to calcium in vegetation and milk have been reported[1,2]. A comparison has been attempted (Table 3) between the observed values in vegetation and in milk with those which would have been expected from the data in Table 2 if contamination had been due to absorption from the soil. This comparison is not precise as no results are at present available for samples representative of the country's agricultural production as a whole. With regard to milk it has been assumed that there is a discrimination factor of 0·14 against strontium relative to calcium in its passage to milk[5], and that 20 per cent of the calcium in the diet of cattle is relatively uncontaminated (more than 30 per cent of dietary calcium is likely to come from sources which are only slightly contaminated relative to grass, for example, roots and 'concentrates'). In only a few cases, noted in Table 3, has it been possible to make allowance for variations in the deposition of strontium-90 from one part of the country to the other or for the level of soil calcium. The results of surveys of permanent pastures in hill areas[1] have been excluded for reasons which are discussed below. A further source of error in the present comparison is that the lack of quantitative data has made it necessary to assume that the ratio of strontium-90 to calcium in the edible tissues of vegetables is similar to that in the whole plant.

Table 3 shows that for milk and permanent pastures the observed values exceed those expected if absorption occurred from the soil by factors of 8–15. This suggests that more than 80 per cent of the strontium-90 in these materials has not passed through the soil. For the annual vegetable crops the values approach more closely to 1; thus it appears that the major fraction of the strontium-90 in these crops was absorbed from the soil excepting possibly only lettuce, the one vegetable examined of which the exposed leaves are edible (the interpretation of the results for potatoes is difficult since they were not peeled prior to assay).

An examination of results for hill pastures strengthens the inference that the contamination of permanent grass cannot be attributed to absorption from the soil. Ratios of strontium-90 to calcium ranging up to 2,100 $\mu\mu$c. strontium-90/gm. calcium are reported, that is to say, nearly 50 times the mean for lowland pastures[1]. As soils comparable to those of these hill areas were not employed in the field experiments, the quantity of strontium-90 which would have been expected to be absorbed from soil cannot be estimated by the method adopted in Table 3. Some basis for assessing the extent of absorption from the soil is, however, possible from the results of preliminary laboratory experiments, in which rye-grass was grown in soil from these areas which had been contaminated with strontium-89. A comparison of the results of the tracer experiments and field surveys suggests that the ratios of strontium-90 to calcium in native vegetation of different types are 4–40 times greater than would have resulted from absorption from the soil[16].

Since milk is at present the major route whereby strontium-90 reaches human diet it is particularly important to interpret the mechanism whereby strontium-90 enters the herbage of permanent pastures which cattle graze. As the contribution of strontium-90 from the soil appears to be relatively small, the major route of entry must be through leaves, stems or surface roots. Direct foliar absorption is the mechanism other than absorption from the soil which has been considered in the majority of discussions hitherto. Entry by this route would be expected to depend on the rate of deposition during the growing period of leaves, that is to say, it should be a function of the annual rate of fall-out. Data for lowland pastures and for milk in the United Kingdom are reasonably compatible with this interpretation. In the period 1955–56 when the rate of annual fall-out was relatively constant and the cumulative total

Table 4. COMPARISON OF DEPOSITION OF STRONTIUM-90 AND LEVELS IN MILK IN THE UNITED KINGDOM AND IN THE UNITED STATES OF AMERICA

	Cumulative deposition mc./km.^{2}	Milk $\mu\mu$c. Sr-90/ gm. Ca	$\mu\mu$c.Sr-90/ gm. Ca per mc./km.^{2}
Frome, Somerset (*a*)	(1)	(2)	(3)
1955	3·6	4·1	1·1
1956	5·4	4·4	0·81
1957	8·0	5·1	0·64
New York (*b*)			
1953–54	1·9	0·8	0·42
1954–55	3·5	1·25	0·36
1955–56	7·0	2·4	0·34
1956–57	10·8	3·5	0·32

(*a*) from Stewart *et al.* (ref. 15), and Bryant *et al.* (ref. 2)
(*b*) from Eckelmann *et al.* (ref. 20).

increased by a factor exceeding two, levels in milk rose to a comparatively small extent (Table 4).

Direct foliar absorption cannot, however, explain the situation in hill pastures since the ratios of strontium-90 to calcium in them increased between 1955 and 1957 in a manner comparable to the cumulative fall-out[1]. This has led to the suggestion that the high ratio of strontium-90 to calcium in such pastures is due to rapid absorption from soils low in calcium. Evidence already considered suggests that this is improbable; a more cogent reason for rejecting this interpretation is that a major part of the strontium-90 in these areas is in the root mat, not in soil. The permanent unimproved hill pastures of the United Kingdom are characterized by a considerable development of root-mat which consists of organic matter, superficial roots, and the basal portions of stems in varying proportions. Between different habitats the depth and nature of the mat zone varies greatly; in some cases it is many centimetres in thickness. All such mat layers have one characteristic in common: strontium-90 entrapped therein will not have equilibrated with the labile soil calcium. It may therefore be expected to be more accessible to plants than strontium-90 in the soil. To distinguish absorption by this route from direct foliar uptake, and from absorption from the soil, the term 'stem-base' absorption is proposed; it may be regarded as an intermediate condition between the other two mechanisms of entry. Grassland husbandry provides evidence of the magnitude of the 'stem-base' absorption; fertilizers frequently have greater effect when applied superficially to establish grass than when added to soil. Since the stem-base 'reservoir' will not retain strontium-90 indefinitely, entry by this route will be dependent on the rate of fall-out rather than the cumulative total. With annual species it will be expected to be a function of the deposition during the growing seasons but with perennial pastures it will be a function of the deposition during the mean period for which strontium-90 remains in the stem-base reservoir. Thus the apparent relationship between the content of strontium-90 in hill vegetation in the United Kingdom and the cumulative deposition during the period 1954–56 is suggestive that the mean life of strontium-90 in the stem-base reservoir in these areas is several years; the fact that in 1957 soil has been found to contain less than 40 per cent of the total strontium-90 per unit area of pasture in some hill areas supports this interpretation.

Stem-base absorption is therefore considered to provide an explanation of the observed high levels of strontium-90 in hill pastures. This prompts inquiry as to whether the large component of the strontium-90 in lowland pastures which is dependent on the annual rate of fall-out is correctly attributed to foliar absorption or whether it is due to stem-base absorption from a reservoir which in this case retains strontium-90 for a mean period of approximately one year. Several lines of evidence suggest that this may be so. In one of the field experiments already referred to[4] an additional treatment was included in which strontium-89 was applied to established grass in its second year and the ratio of strontium-89 to calcium in the new leaf tissue which developed 5–28 weeks after contamination was nearly twice that in treatments in which strontium-89 had been applied to the surface of the land prior to the germination of grass; stem-base absorption would be expected to be much smaller in such a young sward than in established pastures with the greater mat development.

The possibility that stem-base absorption may be large relative to direct foliar uptake is also encouraged by the fact that when strontium-89 is applied as a spray to leaves, and allowed to dry, considerable losses can rapidly occur through leaching in rain[17]. Thus the quantity of strontium-90 which reaches the stem-base reservoir may well be very much greater than the fraction which remains on leaves.

Surveys of world-wide fall-out in the United Kingdom indicate that the relationship between the ratio of strontium-90 to calcium in plants and the cumulative deposition varies by a factor in the order of 20 between hill and lowland pastures. The data[1], however, show that the relationship between the strontium-90 content of grass per unit area of land and the total deposition is considerably more constant; there is no indication of a significant difference between hill and lowland areas. This encourages the view that the mechanism whereby strontium-90 enters pasture plants may be relatively similar in all cases; the only mechanism which appears compatible with results obtained in both hill and lowland pastures is stem-base absorption. None the less, no unequivocal evidence is available to show the relative magnitude of foliar and stem-base absorption except in hill pastures where the latter appears to be dominant.

Future Relationship between the Rate of World-wide Fall-out and the Strontium-90 Content of Vegetation and Milk in the United Kingdom

Despite uncertainty as to the relative importance of foliar and stem-base contamination in lowland pastures and in annual vegetable crops, it appears that the component of contamination of these crops which is dependent on the rate of fall-out (that is, aD_p in equation 1) is a function of the annual deposition. No precise estimate of the proportionality function a in equation 1 is at present possible, but an approximation can be made by dividing the difference between the values in columns 4 and 5 of Table 3 by the annual rate of fall-out. The resultant estimates of a for milk, lowland pastures and vegetables are shown in Table 5. Values for the proportionality function, which is dependent on the cumulative deposition (b in equation 1), can be derived directly from Table 2 for lowland pastures and for annual vegetables; the appropriate value for milk can be obtained by dividing the value for lowland pastures by 0·14, which is taken as the discrimination factor between strontium and calcium in their passage from the diet of cattle to milk[5]; no allowance for uncontaminated sources of calcium in the diet of cattle is here made, as was done in Table 3, since it is to be

Table 5. Proportionality Factors for the Estimation of Levels of Strontium-90 in Biological Material by Equation 1

Factor	Milk	Lowland pastures	Annual vegetables
a, Dependent on rate of deposition ($\mu\mu$c. Sr-90/gm. Ca per mc./km.^{2} deposited per annum)	1·8	18	2·8
b, Dependent on cumulative deposition ($\mu\mu$c. Sr-90/gm. Ca per mc./km.^{2} total deposition)	0·16	1·1	1·1

expected that in due course all the dietary calcium of cattle will be contaminated to a similar extent.

In Table 6 the values of *a* and *b* shown in Table 5 have been used for calculating the levels of contamination in milk lowland pastures and edible vegetables which may result if world-wide fall-out continues at its present rate. Stewart *et al.*[15] have concluded that a constant rate of fall-out will result in the cumulative deposition in the United Kingdom rising from the 1957 level of 7·5 mc./km.^{2} to 38 mc./km.^{2} in 1967; an equilibrium value of approximately 92 mc./km.^{2} would be attained in a hundred years time. Predicted levels of strontium-90 in milk and vegetation for these two occasions are shown in the table. It is estimated that at equilibrium, when cumulative fall-out has attained twelve times the present level, the contamination of milk and lowland pastures in the United Kingdom will have risen only three to four times; the corresponding value for annual vegetables, the contamination of which is more dependent on absorption from the soil, is seven.

In view of the attention which has been directed to the present relatively high levels of strontium-90 in hill pastures, it is of interest to consider the eventual levels which may be attained in them. The method of Table 6 cannot be used since the rate-dependent component (aT_p in equation 1) cannot at present be assessed. The evidence, however, suggests that this component (that is, stem-base absorption) is greater relative to absorption from soil than in lowland pastures. Thus it is to be anticipated that the eventual values for hill pastures will exceed present levels by smaller factors. In any event, the situation in permanent hill pastures is of relatively small importance in determining the exposure of the population since they provide but a small fraction of dietary calcium.

The very slender basis for the present predictions must be emphasized; it may well be that in the early period the levels in permanent pastures will rise more rapidly than predicted because strontium-90 remains largely in the upper soil layers (Table 1). On the other hand, the eventual level is likely to be reduced both because no allowance has been made for the strontium-90 removed in crops and animal produce each year and because leaching and the removal of strontium-90 in surface-wash from sloping land may cause the cumulative level in the soil to fall significantly below the total cumulative deposition. Such losses of strontium-90 should in general be expected to be greatest in leached soils which are low in calcium; thus with the passage of time the effect of soil calcium indicated in Table 3 may be reduced. The regular application of lime would also reduce the effect of soil calcium. A further reason why the present calculations may over-estimate the eventual level of strontium-90 in plants is that, in the field experiments, the radioactive tracer was not as uniformly distributed in the soil as would occur after continued cultivation.

Release of Strontium-90 in Accidents: Relationship between Deposition and the Contents of Plants and Milk

The circumstances of an accidental release are likely to differ from world-wide fall-out in two respects. First, the deposition may be of relatively short duration; secondly, whereas world-wide fall-out is carried down largely in rain[15] the deposition resulting from accidents may consist of particles of considerable size. Since particles exceeding 40μ are relatively little retained in vegetation[18], foliar uptake may vary greatly; furthermore, the biological availability of the deposition may show similar variability. It is, therefore, impracticable to predict the magnitude of the proportionality factors *a* and *b* for equation 1. The maximum level in vegetation which grows in land cultivated after the deposition should, however, be given by equation 2; low biological availability may on occasions introduce a large protective factor.

Comparison of the Rates of Entry of Strontium-90 into Plants under Different Climatic and Agricultural Conditions

From the foregoing it is apparent that the nature of vegetation can cause large differences in the relative magnitude of the components of plant contamination which are respectively dependent on the rate of deposition and on the cumulative deposition. If the component which is dependent on the rate of fall-out is large the current level of contamination would be expected to be relatively high, but with the passage of time it will not increase as rapidly as in areas where

Table 6. Prediction of Future Contamination of Milk, Lowland Pastures and Annual Vegetables with Strontium-90 assuming that Fall-out continues at its Present Rate

Material	Year	Cumulative deposition		$\mu\mu$c. Sr-90/gm. Ca in biological material			
		mc./km.^{2}	relative to 1957	Component dependent on rate of deposition (aD_p in equation 1)	Component dependent on cumulative total (bD_T in equation 1)	Total	Ratio: $\frac{\text{total}}{\text{1957 value}}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Milk	1967	38	5	4·1	6	10	2
	2057 (equilibrium)	92	12	4·1	14·5	19	4
Lowland pasture	1967	38	5	40	42	84	2
	2057 (equilibrium)	92	12	40	101	140	3
Annual vegetables	1967	38	5	7	42	50	3
	2057 (equilibrium)	92	12	7	101	108	7

Columns 3 and 4 from Stewart *et al.* (ref. 15); column 5 calculated by multiplying annual rate of fall-out (ref. 15) by values of (*a*) shown in Table 5; column 6 calculated by multiplying column 3 by values of factor (*b*) in Table 5.

contamination is primarily dependent on the cumulative deposition.

It is of interest to compare the relationships between the cumulative deposition and the strontium-90 content in milk for Somerset and New York in the past four years (Table 4). In the United Kingdom the levels in milk have risen to only a small extent, although the cumulative deposition has been more than doubled ; in New York, however, the cumulative deposition and the levels in milk have both risen similarly. Moreover, the ratio of the level in milk to the cumulative deposition on Somerset (Table 4, col. 3) is considerably above the relatively constant United States value ; the over-all rate of transfer of strontium-90 to milk is, therefore, considerably greater. This is perhaps attributable in part, at any rate, to the conditions of United Kingdom pastures being more favourable for stem-base absorption. These differences indicate the danger of extrapolating from one region to another. This danger is likely to be particularly great when the manner of growth of crops contrasts markedly. It might be expected that the component of plant content which is dependent on the rate of fall-out will be particularly great in plants growing in soil submerged in water, particularly if ions can be absorbed largely from the water as opposed to the soil ; this could be regarded as an extreme case of stem-base absorption. A report that the total radioactivity of the bog moss *Sphagnum* in the United Kingdom has increased to a considerably greater extent than that of land plants[19] is compatible with this view. Rice grown in flooded paddy fields would seem to provide the opportunity for an analogous large component dependent on the rate of contamination. Relatively high levels of contamination in rice have been reported, but the evidence does not enable the mechanism of contamination to be assessed.

Hitherto it has usually been considered that variations in the rate of transfer of strontium-90 from the ground surface into human diet will be influenced mainly by the importance of milk produce in the diet and by the calcium content of soil. It now appears that this analysis is inadequate ; variations in the growth forms of both roots and shoots may cause considerable differences in the relationship between plant content and both the rate of fall-out and the cumulative total. The results of field surveys, conducted for at most a few years, appear wholly inadequate for elucidating these complex relationships. If long-term predictions are to deserve credence, careful experimental work is necessary.

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OBITUARIES

Prof. S. R. Milner, F.R.S.

PROF. SAMUEL ROSLINGTON MILNER died at the home of his son in Sydney, New South Wales, on August 12, at the age of eighty-three. For some time his health had not been good, but he continued working to the end. An understanding friend has written of him : "In the entirely selfless absorption in science for truth's sake there cannot have been at any time many equals of S. R. Milner".

He attended King Edward VI School, Retford, and the Universities of Bristol and Göttingen, under Chattock and Nernst. After one year on Schuster's staff in Manchester he worked in Sheffield as a lecturer with Hicks from 1900 until 1917, as acting professor until 1921 and as professor until his retirement in 1940. During the First World War he enlisted in the R.A.M.C. as radiographer to the Third Northern General Hospital, designing and building the necessary apparatus and training men for other hospitals.

In spite of a heavy burden of teaching in an understaffed Department, Milner fulfilled his early promise by a fruitful output of both theoretical and experimental research. At the early age of twenty-five he was awarded the London D.Sc. and later received honorary doctorates from both Bristol and Sheffield. A beautiful and ingenious experimenter, it was a delight to watch his careful construction and manipulation of apparatus. Students will always remember his lectures, which were models of lucidity and copiously illustrated by demonstrations, many of his own devising.

His colleagues and others had a tremendous admiration for his encyclopædic knowledge of physics ; but it was his theoretical work on solutions, and later on electromagnetism, which brought him his greatest distinction. Considering first the effect of the departure from the ideal gas laws of the ions in solutions (1900), he developed his ideas in further papers and laid the foundations of the modern theory of electrolytes (1912–1918) in papers on "The Virial of a Mixture of Ions" and "The Effect of Interionic Forces in Electrolytes". For this work he was elected to fellowship of the Royal Society in 1922. Though these papers were necessarily mathematical, he kept the physical basis in the foreground, and this was true also of his later approach to electromagnetic theory. He examined first the motion of, and stresses in, tubes of force and built up an analysis of the field into moving elements before his thought matured into more mathematical expression of the 'action' of an electromagnetic field, on which his later work was based. He found tools for the development of his ideas in Eddington's 'E-number' calculus, which he reduced to order, obtaining thereby a new insight into the roots of relativity. Thus he was enabled to formulate for the first time a self-consistent classical theory of electromagnetism. At the time of his death he was engaged in the preparation for publication of further papers in which this theory is expounded.

Milner was the most lovable of men. His outstanding characteristic was his capacity for inspiring affection. He was the friend of all because he was so willing to be friendly and helpful in a rather shy and retiring way. His genuine interest in the welfare and careers of his students was recognized and appreciated by them. Together with his colleagues and many others, they had for him a very deep affection. He is survived by his wife, also a physicist from the University of Bristol, and son, who is professor of physics in the New South Wales University of Technology, Sydney.

J. R. CLARKE

Mr. S. E. Fox

MR. SEATON E. FOX, who was sixty-five, died in a London hospital on August 27 after a short illness. He was a graduate of the University of Cambridge and in 1932, after working for several years in the explosive and petroleum industries, he became assistant secretary and technical editor to the Technical Section of the Paper Makers' Association, and in 1944 he was appointed librarian, information officer and editor to the British Leather Manufacturers' Research Association, a post he occupied until his death.

During his fifteen years work for the Association, Mr. Fox organized its publications on a sound basis and brought them to a high technical and editorial standard. He began the abstracting system which has proved so useful to members of the British Leather Manufacturers' Research Association: his index of publications on collagen is valued not only by his colleagues and others in the leather industry but also by scientists engaged elsewhere in pure research on that subject. His work was highly respected by librarians and editors in other research associations, and his death is greatly regretted by them and by his many friends and acquaintances in the leather industry.

NEWS and VIEWS

The Danish Atomic Energy Commission

THE main task of the Danish Atomic Energy Commission, which was constituted on December 21, 1955, and which meets regularly once a month under the chairmanship of Prof. Niels Bohr, is the planning and construction of Risö, its research establishment, situated on a 650-acre site four miles north of Roskilde, a town of 30,000 inhabitants, and twenty miles west of Copenhagen. Through the co-operation of the United States of America and the United Kingdom the establishment will eventually have the facilities of three research reactors. DR1 (Danish reactor No. 1) is a low-energy, homogeneous reactor, particularly suitable for educational purposes and physical experiments. It was purchased in the United States in July 1956, together with DR2, which is a light-water-moderated heterogeneous tank-type research reactor with facilities for neutron exposure experiments and isotope production. DR3, purchased in the United Kingdom in June 1957, is a heavy-water-moderated high-flux reactor of the PLUTO-type as constructed for Harwell and Dounreay. Work on DR1 was completed on August 15, 1957, and DR2 and DR3 are expected to become operational during 1958 and 1959, respectively. Details of the layout of the establishment and of the components of the reactors, together with illustrations of the various ancillary buildings, are given in an attractive brochure which has recently been issued by the Commission (Risö: The Research Establishment of the Danish Atomic Energy Commission. Pp. 20. Copenhagen K: Danish Atomic Energy Commission, 1958). The staff of the Scientific and Technical Department on April 1, 1958, totalled 143, distributed among the six groups of the Department—reactor engineering, physics, chemistry, electronics, health physics and agricultural research. In addition, fifty-one people were employed in the administrative office and the various service departments at Risö and thirty in the secretariat of the Commission at its headquarters in Copenhagen.

Seventy-fifth Anniversary of L'École Supérieure, Paris

To commemorate the seventy-fifth anniversary of the foundation of L'École Supérieure de Physique et Chimie Industrielle in Paris in 1882 the student association has recently issued a most attractive and interesting illustrated volume containing twenty-four articles dealing with chemical and physical topics (Association des Élèves de l'École Supérieure de Physique et Chimie Industrielles de la Ville de Paris. Physique et Chimie. Ouvrage édité à l'Occasion du 75e Anniversaire de leur École. Pp. 272. Paris, 1959). In the first two articles, Prof. R. Lucas, the director of L'École Supérieure, and Prof. L. de Broglie pay tribute, respectively, to the founders and to the many famous past pupils of the institution, and one of these pupils, Paul Langevin, is also the subject of a separate article by Prof. M. Tournier. The articles by the late Prof. F. Joliot on energy and its utilization, Prof. G. Destriau on the phenomena of luminescence, and Prof. J. J. Trillat on electron diffraction, will perhaps be of greatest interest to the physicist; and to the chemist, the articles describing the French chemical industry, polyamide textiles, quantum chemistry, and plastics. There are in addition articles dealing with optical methods for the study of the flow of liquids; the optics of high-frequency aerials; and the visibility of submerged objects. In the final article in the volume Prof. D. Gabor gives a detailed and clear description of his flat colour-television tube which has aroused so much interest both in Britain and overseas.

University College of the West Indies

It is widely recognized that a degree course in agriculture should be available in the West Indies, and for some time the Council of the University College of the West Indies and the Governing Body of the Imperial College of Tropical Agriculture have considered how to provide it. The Governing Body of the Imperial College of Tropical Agriculture has recently proposed that the Imperial College should merge its identity in the University College of the West Indies and become its School of Agriculture. The Council of the University College has welcomed the proposal and is discussing means of giving effect to it in the near future. The degree course would replace the present course for the diploma of the Imperial College of Tropical Agriculture, but the other activities of the Imperial College, including its post-graduate teaching and research, would be continued in Trinidad under the auspices of the University College. At the request of the two Colleges the Secretary of State for the Colonies has agreed to the secondment of Sir Stephen Luke from the Colonial Office to assist them in the preparation of a scheme.

Professional Civil Servants

In an article on "The Role of the Professional Civil Servant" reprinted from *Scientific Service in State Service* of August, Sir Graham Sutton expresses the view that in the future it will be increasingly necessary for professional Civil servants to participate in administrative functions: the management of a research group or of any part of a Ministry concerned with scientific and technical matters should be largely in the hands of men with professional knowledge. Sir Graham regards the making of decisions on the basis that he who is completely ignorant cannot be biased is a most dangerous feature of to-day and agrees, on the other hand, that the whole basis of scientific training makes it extremely difficult for the scientist or engineer to go against the weight of evidence. Accordingly, he suggests, a main problem facing professional Civil servants is how to ensure that an adequate knowledge of administration and management is passed on to the young professional man in his formative years. He believes that in any well-balanced government service of the future the fundamental position of the technically trained man must be recognized and that he should be given some training officially in administration. The professional Civil servant must endeavour to carry on the tradition of integrity, freedom from corruption and life-time devotion to duty irrespective of financial reward which had marked the Civil Service, but from the point of view that he is no longer an adviser, but likely to be the man who will actually make decisions because he alone is able to understand the scientific principles involved.

Business Schools

In an article, "The American Business School", in the *Westminster Bank Review* of May last, Mr. O. S. Hiner describes briefly these institutions and their close relations with industry and with commerce, on which their effective operation depends. First degrees in commerce and business rose from 1,559 in 1920 to a peak of 72,137 in 1950 and were more than 40,000 in 1955. The expansion has been due partly to the readiness of the universities to recognize and meet a need, though the provision made has not always been commensurate with their facilities and available teaching staff. The American Association of Collegiate Schools of Business was formed to promote and raise standards, and 90 out of about 170 undergraduate and graduate schools are members. In the belief that decisions in business require increasingly managers with a wide, balanced outlook, the business schools are offering courses intended to produce the 'general' man rather than the specialist, and they claim that their task is primarily to help provide, not departmental heads, but general managers of the future. Besides consulting work by the staff, business schools often undertake research at the request of industry, and there is also a strong demand for development programmes intended to prepare men who have attained senior positions as specialists to undertake more general managerial responsibility. Mr. Hiner suggests that these schools constitute a vital element in the range of educational possibilities and that such institutes in Britain could fill a gap in our existing educational arrangements to produce the managers we need.

Water Pollution

The Department of Scientific and Industrial Research is issuing a quarterly series of leaflets dealing with different aspects of water pollution and its control, one object of which is to direct the attention of industry to the work of the Water Pollution Research Laboratory, the scope of which is being extended with the help of a considerable financial contribution from the Federation of British Industries. The first of these leaflets (Notes on Water Pollution Research, No. 1, June 1958. Pp. 3. (Stevenage, Herts: Water Pollution Research Laboratory, D.S.I.R., 1958)) deals with the effect of organic discharge on the level of oxygen in a stream. It points out that information is particularly required on the rate at which rivers of different depths will absorb oxygen from the air and states that particular attention is to be given to the study of this property of rivers in the future programme of the Laboratory.

Animal Behaviour

The renewal of interest in the scientific study of animal behaviour, now generally known as ethology, which is one of the more remarkable features of the development of zoology in the past twenty-five years, has been marred by a lack of communication between the different schools of thought and between workers in different countries. This has given rise to a good many misunderstandings and needless arguments. In particular, the European school of behaviour students, who are mainly interested in the analysis of the more stereotyped kinds of behaviour of groups such as insects, birds and fish, were—partly as a result of the War—almost completely out of touch with the work of comparative psychologists (the 'rat psychologists') in the United States. These barriers have fortunately been falling rapidly in the past few years and there is now much less provincialism of outlook than there was. A welcome further step in the process of bringing two of these groups together is the metamorphosis of *The British Journal of Animal Behaviour* into a new journal to be entitled *Animal Behaviour*. This is the result of a liaison now established between the British members of the Association for the Study of Animal Behaviour, which was instituted in 1936 and published the original journal as the *Bulletin of Animal Behaviour* in 1938, and their American colleagues. This has resulted in a much enlarged journal, which is certainly necessary to cope with the great increase in papers in this subject, and will enable the editorial staff, which now includes American as well as British members, to accept additional American contributions without reducing the publication facilities which were available to the original members of the Association. It should also result in a greatly increased circulation. It is obvious from a perusal of the first volume of the new journal (which fortunately has not commenced re-numbering its volumes but is issued as Vol. 6, Nos. 1 and 2. Pp. 126 + 4 plates. Published twice yearly. Annual subscription 50*s.*; United States and Canada 8 dollars. London: Baillière, Tindall and Cox, Ltd., 1958) that it is the intention of the editors to maintain the existing high standard. The new venture should be warmly welcomed and given every encouragement.

Courses in Higher Technology

The London and Home Counties Regional Advisory Council for Higher Technological Education has produced a bulletin (Bulletin of Special Courses in Higher Technology, including Management Studies and Commerce, 1958–9, Part 1: Autumn Term. Pp. 122. (London: London and Home Counties Regional Advisory Council for Higher Technological Education, 1958.) 3*s.*) giving details of special advanced courses held in the London and Home Counties region which do not regularly appear in college calendars or prospectuses as part of a grouped course or as subjects offered for endorsement on Higher National Certificates. They are, as a rule, part-time (usually evening) courses, but full-time courses which are specially arranged and are not of longer than three months duration are also included. Sessional evening postgraduate courses leading to higher degrees in science (including mathematics) and engineering are not included in the Bulletin. Among the courses are macromolecular chemistry and structural design in aluminium at Battersea College of Technology; physical methods of assessing flour quality and pulse techniques at the Borough Polytechnic; applied ultrasonics at Brunel College of Technology; taxation case law at the City of London College; technical Russian at the Ewell County Technical College; and bacteriology for public health engineers at the Imperial College of Science and Technology.

The Night Sky in October

New moon occurs on Oct. 12d. 20h. 52m. U.T., and full moon on Oct. 27d. 15h. 41m. The following conjunctions with the Moon take place; Oct. 2d. 18h., Mars 2° N.; Oct. 17d. 01h., Saturn 3° S.; Oct. 29d. 19h., Mars 3° N. There will be a total eclipse of the Sun on October 12, invisible at Greenwich. Mercury is too close to the Sun for observation. Venus is a morning star, but is now unfavourably placed for observation. Mars rises at 19h. 40m., 18h. 45m. and 17h. 25m. at the beginning, middle and end of the month, respectively; it is visible throughout the night. Its stellar magnitude increases during the month from − 1·1 to − 1·8, its distance from the Earth decreasing from 56 to 46 million miles. Mars moves eastwards until October 9, when it reaches a stationary point. It is then between the Pleiades and the Hyades. After October 9, Mars begins to retrograde but it remains in Taurus throughout the month. Jupiter is too close to the Sun for observation. Saturn sets at 20h. 35m., 19h. 45m. and 18h. 50m. at the beginning, middle and end of the month, respectively; the planet may be visible for a short time low in the south-west after sunset, but conditions for observation are not favourable. Occultations of stars brighter than magnitude 6 are as follows, observations being made at Greenwich: Oct. 3d. 03h. 16·6m., δ Tau. (*D*); Oct. 3d. 03h. 59·6m., δ Tau. (*R*); Oct. 3d. 05h. 00·8m., 64 Tau. (*R*); Oct. 8d. 03h. 15·1m., A^2 Cnc. (*R*). *D* and *R* refer to disappearance and reappearance, respectively. The Orionid meteors are active during the third week of the month, conditions being moderately favourable; the radiant is near R.A. 6h. 24m., Dec. + 15°.

Announcements

Dr. Henry S. Odbert has been appointed programme director for psychobiology, Division of Biological and Medical Sciences, U.S. National Science Foundation. Dr. Odbert was formerly chief of the Occupational Analysis Branch of the Personnel Laboratory of the Wright Air Development Center, Lackland Air Force Base, Texas.

Dr. B. Cinader has resigned from the post of principal scientific officer in the Department of Experimental Pathology at the Agricultural Research Council Institute of Animal Physiology at Babraham, Cambridge, and has been appointed head of the Subdivision of Immunochemistry in the Ontario Cancer Institute and associate professor in the Department of Medical Biophysics of the University of Toronto (500 Sherbourne Street, Toronto 5).

The International Trust for Zoological Nomenclature announces that it has accepted with regret the resignation of Mr. Francis Hemming as a member of the Trust and as managing director and secretary. Lt.-Col. F. J. Griffin, who is an original member of the Trust, has been appointed managing director and secretary. Mr. R. V. Melville, who has been acting assistant manager, has been appointed scientific controller, with responsibility for the scientific and editorial work hitherto carried out by Mr. Hemming.

A symposium on "Batteries" will be held at the Signals Research and Development Establishment, Christchurch, Hants, during October 21–23. Further information can be obtained from the Organizer, Battery Symposium, at the above address.

The second Technical Convention of the Indian Institution of Telecommunication Engineers will be held in New Delhi on December 27 and 28, when papers will be read on the following subjects: antenna and wave propagation, broadcasting in India, tropicalization of communication equipment, semiconductors, telephone communication in India, navigational aids, atmospheric and radio noise. Papers intended for presentation at the Convention should preferably deal with original investigations or describe developmental work embodying novel features. The last date for the receipt of abstracts of proposed papers is October 15. Further details may be obtained from the Honorary Secretary, Institution of Telecommunication Engineers, Post Box No. 481, New Delhi.

Erratum. In the communication entitled "Dissociation of Serological Complexes of Ovalbumin and Hæmoglobin using Aqueous Carbon Dioxide", by Dr. B. T. Tozer, K. A. Cammack and Dr. H. Smith, published in *Nature* of September 6, p. 669, column 2, line 6 should read "confirmed by measurements of light absorption at 410 mμ", and not "confirmed by measurements of light at 410 mμ" as printed.

CONFERENCE ON PLANT BREEDING

THE eighth Plant Breeders' Conference was held at the Welsh Plant Breeding Station, Aberystwyth, on July 2 and 3. Participants included representatives of nine research stations in the United Kingdom together with representatives of universities and other institutions at home and abroad.

Members of the Welsh Plant Breeding Station and also Mr. J. L. Fyfe of the Plant Breeding Institute, Cambridge, opened discussions on problems relating to the breeding and assessment of grasses, clovers, cereals and field beans.

Mr. Elfed J. Lewis described an experiment designed to assess, by means of a diallel cross, the potential breeding value of plants selected from an outbreeding species (perennial rye-grass). The data were analysed to determine the usefulness of the diallel technique as a rapid means of obtaining the information required.

It was found that increase in hay and aftermath production showed high average dominance, uncomplicated by non-allelic interaction, indicating that there was no specific combining ability among the plants involved. This implies that improvement could be achieved by the accumulation of favourable dominant alleles, and this is borne out by the fact that the plants from the improved strains show a relatively higher degree of homozygosity for the dominant genes giving favourable expression.

During the discussion it was emphasized that the high degree of homozygosity shown in plants from certain of the bred strains did not necessarily mean that these plants were homozygous for all genes, but rather for those genes by which the plants involved differed, and that the information derived was heavily weighted with regard to the degree of dominance exhibited.

The genetics of production characters in rye-grass were dealt with by Dr. J. P. Cooper, who stressed the importance of three parameters: the amount of genetic variation available, its accuracy of measurement and its heritability. Estimates of these parameters had been obtained for several agronomic characters in local and bred strains of rye-grass.

Heading behaviour had been subjected to the most detailed study; the data for replicated clones showed little variation between blocks within one year, and high repeatability between years. Heritability was also high and most of the genetic variation is additive, but all plants were heterozygous for genes controlling date of heading, and a small group of plants of similar phenotype could carry much potential genetic variation.

Pilot studies indicate that length of leaf and rate of leaf appearance were highly heritable, but this was less marked for the rate of tillering. Italian rye-grass and both Irish and *S*23 perennial rye-grass contain appreciable additive genetic variation for these components, and response to selection should thus be possible. Most plants are highly heterozygous for genes controlling these vegetative characters.

Dr. Keith Jones dealt with the cytological basis for interspecific hybridization in cocksfoot breeding. A classification has been made of a wide range of material into diploids ($2n = 14$) and tetraploids ($2n = 28$) and the extent of aneuploidy was determined. No appreciable chromosomal differentiation was found between diploids and tetraploids or between different tetraploids. It now seems quite possible to combine genes from diploids and tetraploids, for when triploids were crossed with either diploids or tetraploids the most common progeny types had the same chromosome number as the male parent, and chromosome pairing in them was complete and stable.

Dr. M. Borrill showed that the diploid subspecies had a restricted geographical distribution and that they intercrossed freely and produced fertile hybrids. Similarly the geographical races of tetraploids had produced fertile hybrids. As the extensive genic differentiation had not reduced hybrid fertility, any potentially useful genetic type could be utilized by the breeder; for example, a diploid from Portugal and some Mediterranean races which have winter green growth and desirable foliar characteristics.

Mr. W. Ellis Davies read a paper on the number of plants required as the basis of a strain of red clover. Sixteen experimental strains had been produced from a population of Montgomery red clover; they were based on 3, 6 or 12 plants taken at random, with a control based on 200 plants. The control strain gave a similar yield from the second to the fifth generation; the other strains showed an average decrease in yield of green matter, but this was due largely to the strains based on three plants. One of the latter strains yielded 50 per cent above control in the second generation but it showed a rapid decrease thereafter. When the number of plants in the base of the strain is increased the mean yield approximates the control. On the other hand, evidence was produced showing that improvement could be effected by restricting the base to a limited number of superior plants.

Mr. J. L. Fyfe spoke on the evaluation of inbred lines of lucerne; his data on single crosses between second inbreds showed that reciprocal differences were negligible and that contributions made by specific combining ability are usually not statistically significant; inferior lines could be eliminated by tests of general combining ability. A linear relation appears to exist between yield and inbreeding coefficient, which should be considered in comparing single-cross or test-cross with double-cross performance.

The use of polyploidy and species hybridization in the breeding of forage legumes was discussed by Dr. Alice M. Evans. Her results showed that induced polyploidy in *Trifolium pratense*, *T. repens* and *Medicago sativa* could produce higher yields and that reduced fertility could largely be restored by continued selection. By using some of the newer techniques, a few species of *Trifolium* were found capable of inter-hybridization and thus the introduction of new genes into these species had become possible.

Mr. Ll. Iorwerth Jones presented data to show that the height of cutting when sampling herbage plants with different habits of growth affected the assessment of their yield and that the management practised affected the subsequent production of the swards based on different strains of a species. It was impossible to obtain one assessment figure to express the value of a strain relative to another when tested under different conditions; trials involving grazing had given different results from those based on cutting.

An outline of the problems of introducing new variability into cultivated oats through 6× amphidiploids and the induction of mutations was given by Dr. D. J. Griffiths. With the view of introducing genetic factors such as disease resistance into cultivated hexaploid varieties, experimental 6× amphidiploids had been produced through crossing tetraploid with diploid species followed by colchicine treatment. Representative plants from A_2 and A_3 generations of 6× amphidiploids developed from *A. barbata* × *A. strigosa* subsp. *hirtula* had been crossed with natural hexaploid species as well as with other amphidiploids. The data produced on disease reactions, fertility and morphological characteristics of the F_1 generations were discussed in relation to practical breeding.

In his paper on problems of selecting for yield in oats Mr. J. D. Hayes indicated that improvements had been achieved by concentrating on major factors limiting yields such as straw length and disease reaction. Further improvement must, however, be based on increase in yield of grain, and tests capable of detecting differences of 10 per cent or less are required. A large number of replications were required at present to achieve this precision, but the error variance could be reduced in various ways. Some problems associated with early generation testing were raised; it was suggested that the area of land used for this test should be greatly increased.

Dr. D. G. Rowlands had found that *Vicia faba* showed cytological irregularities of a type normally associated with the inbreeding of a naturally outbreeding species; this was confirmed by controlled pollination experiments. The existence of both cross- and self-sterility has been found; inbreeding resulted in reduced pod and seed formation as well as in many sterile plants, but occasional plants produced pods and seeds satisfactorily. Although hybrid populations had shown consistent superiority over inbreds, long-term improvement of field beans must be sought through the development of self-fertile lines; in the meantime improvement in yield may be possible by producing synthetic varieties.

Informal discussions were continued during the afternoons at demonstrations of the work of the Station in the breeding grounds, greenhouses and laboratories of the new headquarters, Gogerddan, near Aberystwyth.

Lolium multiflorum × *Festuca arundinacea* derivatives in which fertility had been restored by doubling the chromosome number were demonstrated. Several potential strains of grasses bred for the colder months when grass is normally scarce were shown as well as the wide range of diploid and tetraploid ecotypes of *Dactylis*. The work in cytology included investigations of inter- and intra-specific relationships of grasses and cytological surveys of field populations. The laboratory techniques for uncovering genetic variation in *Lolium* and *Phleum* under controlled photoperiod and temperature were illustrated and also the application of this rapid technique for strain identification. The herbage legume breeding programme included the production of higher-yielding, late-flowering red clover, larger-leaved and more persistent types of white clover and lucerne for high rainfall areas. Studies on the inheritance of flower colour in lucerne and lucerne selections for tolerance to manganese deficiency were demonstrated.

In the work on oats, emphasis was laid on improvement of yields for different levels of fertility, resistance to stem eelworm and mildew and the use of irradiation for improvement of winter varieties. The value of diallel crossing for barley and wheat breeding was under investigation. Improvement in yields and early ripening was sought in field beans. In the rape crop the chief aims were improvement in frost resistance and leafiness; the effect of hybridization on plant vigour was shown.

Studies of agronomic techniques for the assessment of herbage strains were seen and also agronomic studies of potential strains of grasses. The effects of management of grasses grown in wide drills and as clones on the subsequent seed crops were under investigation and also the effect of density on grass seed yields. Gibberellic acid was used in seed-production studies of late-flowering red clover. Routine laboratory determinations of fibre and nitrogen contents are made for the breeders and agronomists and investigations of soil nutrients are in progress.

GWILYM EVANS

THE MACAULAY INSTITUTE FOR SOIL RESEARCH

THE main body of the annual report (1956–57) of the Macaulay Institute for Soil Research, Aberdeen (pp. 66; from the Institute at Craigiebuckler, Aberdeen; 1958), is devoted to the work of the Pedology Department. The soil survey of the country around Banff, Huntly and Turriff, Jedburgh and Morebattle, and Kilmarnock has been completed. The typical horizons of the seven major soil groups so far encountered are listed. (Full details will be found in the three appropriate memoirs published by the Soil Survey of Scotland.) Other sections of the Pedology Department contribute to the ecology of peat pollen analysis and Quaternary research, bog cultivation and reclamation, studies on Scottish soils, problems of phosphate fixation, rock weathering, the application of differential thermal analysis to clay mineralogy, etc.

The Department of Spectrochemistry has done collaborative work on trace elements in addition to the investigation of spectrochemical methods of analysis concerning flame, arc, spark and pulsed arc emission. Differences in the infra-red absorption spectra of di- and tri-octahedral clay minerals as well as smaller differences between individual minerals in each group have been observed. Infra-red spectrometry has also been applied to the identification of organic compounds in microbial metabolism. Modification of absorption spectra are described due to the presence of bases in alcohols and sodium ions in potassium bromide in ultra-violet and infra-red spectrometry.

The work of the Biochemistry Department embraces: the lignin derivatives, carbohydrates and amino-acids in soils and peats; the metabolism of soil micro-organisms in relation to the biological synthesis of 6-O-acetyl-D-glucopyranose and acetyl-glucose, and the β-oxidation of aliphatic hydrocarbons and herbicidal fatty acids; and the determination of the organic acids, amino-acids and water-soluble carbohydrates in plants. A short note on special methods is also included.

The Plant Physiology Department reports work on mineral balance principally (including major element interaction and the NO_3^- : $NH_4^{\cdot}$ effect). Respiration studies include the sensitivity of dwarf shoots of larch and cedar to potassium cyanide and the metabolism of disks of storage tissue. Measurements of the cation exchange capacity of roots under toxic levels of various metals are described. The influence of fission products fall-out on the extraneous radioactivity in samples of vegetation has also been examined.

The Department of Soil Fertility has been mainly concerned with interrelated field, pot and laboratory work on crop responses (to the major nutrients, the trace elements and magnesium) of different crops grown on the major soil types, and the distribution, composition and stability of nucleic acids in the soil organic phosphorus. In addition to collaborative work on soil micro-organisms described earlier, the Microbiology Department has investigated the growth of thermophilic actinomycetes from composts and the demethoxylation of simple aromatic compounds by soil fungi and wood-rotting basidiomycetes. A preliminary report on the role of micro-organisms of the root region in the phosphate nutrition of plants is given.

Brief accounts from the Forestry, Radioactivity and Statistics Sections are also included.

AGRICULTURAL HISTORY IN HOLLAND

In England the study of agricultural history is in the main a discipline that forms part of the departments of economic history in our various universities. For the past five years it has also been stimulated by the founding of the Agricultural History Society. This Society was established by private enterprise, but as it numbers among its members many university personnel from all over the country, and indeed foreign countries, it has intimate relations with the academic institutions where the subject is being studied.

It is of the greatest importance in Holland, where the progress of farming has been an example and a lesson to other European countries, England in particular. In 1939 a Studiekring voor de Geschiedenis van de Landbouw was privately organized as a Department of the Koninklijk Genootschap voor Landbouwwetenschap, with headquarters at Wageningen. This Studiekring includes Belgian members as well as Dutch. It has published four volumes at intervals since its formation.

Enthusiasm for the subject waxed after the War, and led to the establishment of the Nederlands Agronomisch-Historisch Instituut: Instituut voor Landbouwgeschiedenis at Groningen. This Institute is financed jointly by the Dutch Ministry of Agriculture, the Farmers' Society, the Workers' Unions and the State University of Groningen. It is part of the academic world, and is now directed by Dr. L. S. Meihuizen. Its main work is the preparation of an annual international bibliography of current books, articles and original documents, under the title "Historia Agriculturae". The fourth volume of this publication was issued early in the current year. In addition to the bibliography, records and other important sources for Dutch agricultural history are printed in each volume. Besides this the Institute undertakes the supply of information regarding sources to students and scholars both in the Netherlands and in other countries. To facilitate this work the Institute has collected a considerable and growing library of international works and prepared an extensive documentation. When agricultural archives come to its notice the Institute arranges, when possible, for them to be deposited in the State Archive Library, where they are cared for by the Keeper of State Archives.

In addition to the "Historia Agriculturae" other work currently being undertaken at the Institute is: (*a*) the collection of sixteenth- and seventeenth-century notices of orders issued by the local authorities for the regulation of farming and the marketing of produce; (*b*) a bibliography covering the life and conditions of employment of the Dutch farm worker; (*c*) a study of the economic history of the trade in farm produce in a polder in Zeeland in the nineteenth century. A hand-list of sources for Dutch students of agricultural history is in preparation.

Last year the organization of agricultural history was strengthened by the establishment of a Department of Agricultural History at the Landbouwhogeschool at Wageningen under the direction of Prof. B. H. Slicher van Bath, formerly professor in the State University at Groningen. He will be responsible for a course in agricultural history for undergraduates, and is directing research in the social and economic history of farming in Holland. In this connexion he is editing a series of studies "Historische Sociografieën van het Platteland", the first volume of which, "Een Samenleving onder Spanning: Geschiedenis van het Platteland in Overijssel", appeared last year over his own signature. He continues to act as secretary to the directing board of the Groningen Institute.

A further activity of this Department will be the reorganization of the Agricultural Museum at Wageningen on modern museum lines and its expansion to make it the repository of a collection of early agricultural equipment, implements and tools, and form an adequate instrument for the preservation and study of such things. This work is being done by Dr. J. M. G. van der Poel, formerly director of the Groningen Institute, whose reputation is already known beyond the frontiers of Holland, and who has formulated an imposing plan for the future.

Clearly the Dutch have recognized the importance of the study of agricultural history—both the academic world, the government, and the industry itself.

G. E. Fussell

OPERATIONAL RESEARCH IN ADVERTISING

RESEARCH into advertising has been much intensified in recent years, and it is timely to find that a paper on the subject has been read by Mr. J. Maitland at this year's meeting of Section F (Economics) of the British Association.

The problem studied may be very simply stated. It is to determine the relationship, if any, between the amount of advertising (concerning some article or service) and the response to it. It is supposed that the problem of defining measures of the 'amount of advertising' and the 'response' has been settled previously. Advertising is considered as an example of a stimulus; this stimulus is regarded as the input, and the response as the output. Thus we have an input–output situation of the type well known in experimental psychology, and this leads to a model based on a physiological analogy. Data were taken from five sets of advertising campaigns: (1) advertisement, by way of technical journal announcements and leaflets mailed to medical practitioners, of a vitamin product; (2) mailed leaflets based on the membership lists of learned societies and professional organizations; (3) service recruiting by means of newspaper advertisements, type 1; (4) as in (3), type 2; (5) radio equipment advertised in daily newspapers. The amount of advertising, A, was measured in terms of quantities such as the number of announcements or journal issues or leaflets distributed, while the response, R, was measured in terms of the number of inquiries.

In order to set up a model of the input–output system, three analogies were used—physiological, biological assay and physical.

Physiological analogy. In this case a linear relationship between R and $\ln A$ would be expected. By plotting the data referred to above such a relationship was reasonably suggested. The method of least squares was used in fitting the curve. The linear relationship, $R = a \ln A + b$, where a and b are constants, suggested that: (1) there is a threshold value of advertising below which there is no appreciable response; (2) as the amount of advertising increases a state of saturation is reached in the sense that further advertising produces a negligible response.

These results permit an estimation of the point at which the marginal gain becomes too small to justify increased advertising.

An alternative formulation is in terms of the law of diminishing returns (see Zentler and Ryde, *Management Science*, 2, 337; 1956) and it is found that the response R may be related to the expenditure, x, on promotion by an equation of the form:

$$R = R'y^2/(1 + y + y^2)$$

where $y = x/b$ and R' and b are constants.

The analogy of biological assay. This is the model to use if one is interested in relative rather than absolute response. The numerical data available were analysed to determine the increase in the proportion of the population responding to a prescribed increase in the amount of advertising.

Physical analogy. Here reference is made to the work of Vidale and Wolfe (*Operations Research*, 5, 370; 1957), who introduced the concept of a saturation-level as the practical limit of sales that may be generated as promotional activity is increased in intensity. The mathematics of this case leads to an equation which implies an exponential rise of R to a maximum as advertising intensity is increased. Thus the analogy is that of the charging of an electrical condenser.

The proportions of the population responding to varying degrees of stimulus are compared for the various methods used. There is little difference between the results obtained by the logarithmic law and by the probit analysis, although the former involves less computation. The simplest form of the theory of Zentler and Ryde is not very satisfactory, and a more complex form is inconvenient in comparison with the other alternatives.

ATOMIC POWER IN CANADA

DURING the Second World War, Chalk River, Ontario, was selected by the Canadian Atomic Energy Project as the site for the major research reactor, NRX, which was to be a high-flux reactor fuelled with natural uranium metal, moderated with heavy water and cooled with natural water. The low-energy heavy-water reactor, ZEEP, was first constructed on the site in 1945 and this served as a check on the design of NRX. In 1947, NRX began to operate with a heat output of 30 megawatts. A more powerful reactor, NRU, fuelled with natural uranium metal but both cooled and moderated with heavy water, was then constructed on the site, and this came into operation in 1957 at 200 megawatts. Like NRX, NRU was designed to take advantage of the high neutron flux produced for the production of plutonium and radioactive isotopes for research purposes, but both reactors operate at low temperature and pressure, and in neither is it possible to employ usefully the heat produced.

An increasing proportion of the research and development work at Chalk River was, however, devoted from 1951 onwards to problems related to the provision of economic atomic power, and although direct progress was somewhat slowed down by the accident which occurred to the NRX reactor in December 1952, the successful reconstruction of the reactor and its power increase to 40 megawatts brought valuable confidence in the long-term maintenance and the safety of heavy-water moderated reactors for power. The use of heavy water leads to good economy of neutrons and is one of the best long-term prospects for cheap nuclear power. The gas-cooled, graphite-moderated reactors in use in Great Britain required less development work and, therefore, were brought into operation sooner, but the price at which they produce electricity is for most places in Canada much too high to compete with other available sources of electricity.

Early in 1954 a group, known as the Nuclear Power Branch, was set up in Chalk River to study the design of nuclear reactors for the economic production of power, and a demonstration reactor, known as NPD-2 and proposed by the Branch, is now under construction by the Canadian General Electric Company at Des Joachims on the Ottawa River and is expected to come into operation during 1961. In September 1955, after the decision had been taken to build NPD, the Branch began a study of a full-scale nuclear plant. The results of this study were described in a report in May 1957, but which was given only limited circulation.

However, a booklet* based on the report, giving the background history of the Canadian project and describing in detail the plant designed by the Nuclear Power Branch, has been prepared by J. E. Woolston and has recently been issued. In the first two sections the possible demand for nuclear power in Canada and the general approach to the study including the cost target for a competitive nuclear power plant are discussed. The third section deals in detail with the proposed reactor, which has a thermal power of 794 megawatts and a net electrical output of 200 megawatts. Slugs of natural uranium oxide are used as fuel, and it is cooled and moderated by heavy water. The fuel is housed in horizontal pressure tubes through which the pressurized heavy-water coolant passes. There are 200–250 tubes mounted on a square-lattice with a pitch of one foot. A feature of the design is the high burn-up planned for the unenriched oxide, which is considered to be of greater economic advantage than the improvement of the steam conditions and the rather poor thermal efficiency of the plant. The final sections in the report deal with the range of studies carried out by the Branch and the alternative systems investigated; pertinent Chalk River experience; and the estimate of cost of the nuclear plant and its operation. The names of the members of the staff of the Nuclear Power Branch who participated in the studies leading to the proposed reactor are listed in one appendix, and in another complete data on the main components of the reactor are set out.

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* Atomic Energy of Canada Ltd. The Canadian Study for a Full-Scale Nuclear Power Plant. Pp. 64. (Chalk River, Ontario: Atomic Energy of Canada, Ltd., 1958.) 1.50 dollars.

RESEARCH IN ALBERTA

THE thirty-eighth annual report of the Research Council of Alberta* records generally satisfactory progress in all projects during the calendar year 1957 and also in the recruitment of staff of high calibre. A feature of the year was the development of the geological research and survey operations which led to the initiation of survey operations in the north-east corner of Alberta in the Precambrian Shield area. The expansion of the co-operative basic cloud physics research programme with particular reference to the problem of hail in Western Canada was also noteworthy. In the work on coal, evidence was obtained that the calorific value decreases considerably when coals were exposed to the air for prolonged periods, and the thermograms of several coal fractions and of three dated fossil woods were determined. In other differential thermal analysis studies it was observed that sulphur dioxide can modify extensively the course of the pyrolysis of coal. A study of the grindability of coal was completed, and considerable progress made in studies of fluidized coal carbonization.

A theoretical analysis of the flow of stratified water and oil in horizontal pipe-lines agreed well with experimental observations, and progress is reported in the catalytic desulphurization and oxidation with nitric acid of organic sulphur compounds. The study of detailed trace metal and component geochemistry of four major and several minor oilfields was completed; engineering studies continued on the high-temperature pyrolysis of natural gas and a process was developed for removing nitrogen from natural gas. An infiltration study on a river terrace south of Camrose indicated that certain surface water supplies in Alberta can be purified by this technique. Results obtained in studies on electrosomatic flow into clay soils provide a starting point for computing the power requirements necessary to reduce the moisture content of soil by this method, and besides work on the strength, stability and compaction of a base cover material, the instability conditions in bridge abutments were investigated and the problem of frost action received continued attention.

The biological cycles programme, which was brought to a virtual close by the death of Dr. W. Rowan, has indicated a rather dramatic increase in grouse and rabbit populations in many areas. Studies on the nutritive value of rape-seed oil indicate that fermenting and drying ground rape-seed prior to oil extraction remove two of the toxic factors and that the high temperatures used in extracting the oil may be partly responsible for the varying feeding value of commercial rape-seed oil meals. The adsorption areas of acetylene, ethylene and ethane on Charcoal No. 2222 have been measured, and it appears that the less 'active', finer-pored charcoal may be more valuable for certain dynamic separations of gases, as in chromatographic column, a technique which is proving of increasing value. A weather radar set has been installed at Penhold and used to follow the detailed courses of precipitating storms within 100 miles, while the hail-reporting network now covers some 15,000 square miles in central Alberta. Lapse-time cloud photography was also expanded and the commercial hail-suppression programme operated over 400 square miles in the southern part of the hail project area. Ground-water conditions were surveyed in five districts and the answering of inquiries is an important part of the ground-water programme. The palæobotanical laboratory continued to be concerned chiefly with describing and cataloguing the Edmonton Paskapoo fossil floras in central Alberta, and microslides have now been made of all the species of modern conifer woods in the type collection. A list of publications is appended.

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* Research Council of Alberta. Thirty-eighth Annual Report, 1957. (Report No. 77.) Pp. 56. (Edmonton: Queen's Printer, 1958.)

THE ONTARIO RESEARCH FOUNDATION

THE report of the Ontario Research Foundation for 1957*, which includes a list of papers published during the year, records a slight excess of income over expenditure—33,958 dollars over an expenditure of 1,248,421 dollars, but the Director in his introductory report refers to the curtailment of basic research because the sum available has remained stationary over the past ten years. Additional support has now been requested from the Ontario Government.

In biochemistry, work on the development of tanning materials from waste sulphite liquor has shown that sole leather can be tanned with a phenol condensate in pilot-scale experiments, and large-scale commercial trials are necessary to determine the economics of the process. By impregnating sole leather with mixtures of synthetic resins and plasticizers its rating on an abrasion test machine was increased by 200 per cent, but the result was not confirmed in wear tests on shoes. An edible spread from Canadian edible oils which could be spread at −10° F. and did not 'oil off' at 100° F. was very satisfactory on pilot plant tests, and very encouraging techniques have been developed for separating amino-acids from commercial protein hydrolysates.

Encouraging growth in sponsored research is reported in the Chemistry Department, and three new fellowships were initiated in the Wood Chemistry Section. Studies of the *iso*propyl alcohol extract of waste sulphite liquor and the residual aqueous fraction yielded a new tanning material, and a phenolated high-molecular weight lignin fraction was superior in dispersing properties to the quebracho used in lime-base oil-drilling muds and increased the fluidity of wet concrete. A study of the kinetics of crystallization of calcium sulphate dihydrate from supersaturated solutions showed that, after an initial nucleation period, the process followed first-order kinetics, the rate constant depending on the initial degree of supersaturation. Significant differences have been demonstrated in the corrosion resistance of a Watts nickel deposit as a result of various methods of polishing the steel. A complete revision of the paper chromatographic techniques reduced the errors in analysing phosphate glasses for structural components to those associated with cutting the chromatogram to separate the polymers.

In the Department of Engineering and Metallurgy three new sponsored fellowships were initiated, including one to study the oxidation of nickel at high temperatures. The study of the fundamental fatigue of metals continued with the view of detecting signs of elementary strain or damage during tensile or fatigue loading. Brittle fatigue is being studied with a special jig developed for the purpose and steels for high-temperature service incorporating non-metallic materials by a new design of creep extensometer. High-strength steels of good tensile properties have been produced by rapid heat-treatment methods. In the Ferrous Metallurgy Section hæmatite has been converted to magnetite by flash roasting and magnetite reduced to metallic iron in the jet smelter. The Department of Mathematical Statistics examined sampling procedures for the Bureau of Broadcast Measurement, surveyed the fuel consumption of trucks and buses for the Ontario Department of Transport and continued an extensive programme on sizing systems for garments in co-operation with the Textiles Department, where a satisfactory technique has been developed for measuring the modulus of rigidity of a wool fibre immersed in a liquid, which gives a sensitive means of following changes in physical properties caused by chemical processes. A long-term study was completed of methods for stabilizing viscose rayon fabrics against dimensional changes in laundering.

The work of blood parasites of birds continued with promising results, attention being concentrated on two, *Leucocytozoon* and *Haemoproteus*, which invade the red corpuscles, and the data accumulated show that different kinds of birds have distinctly different types of parasite. A microscopic study of the fine sands from samples of horizons from selected soil profiles was started, and observations regarding evaporation from small plots of grass on moist soil were again taken daily at Norman Hills and at Kapuskasing on the Dominion Experimental Farm.

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* Ontario Research Foundation. Annual Report, 1957. Pp. 35. (Toronto: Ontario Research Foundation, 1958.)

SUPPORT AND DIRECTION OF RESEARCH AT AMERICAN ACADEMIC INSTITUTIONS

IN a symposium on "The Changing Patterns of Academic Research", which had been organized by Sigma Xi, Dr. Lloyd V. Berkner, president of Associated Universities Inc., discussed the support and direction of research at academic institutions in the United States (*Amer. Sci.*, 46, No. 2 ; June 1958). He first examined the direction and balance of effort that is likely to produce the most significant advances to human knowledge. Research problems tend to be in competition among themselves for support, and a single large research effort may involve funds that could generate a great many research efforts on a smaller scale. In management of research, therefore, one is faced with advance assessment of the significance of a large effort in contrast to the integrated significance of a number of smaller efforts which that large effort potentially represents. Having defined research as having goals beyond the limits of human knowledge, it is apparent that such decisions in allocation of research-support require a 'crystal ball'.

Berkner arbitrarily divided research activities according to the size of the effort involved as follows : (1) conventional research on an individual scale involving essentially 'string and sealing wax techniques' or corresponding theoretical activity ; (2) group research in a particular area or discipline of science involving modest tools; (3) group research of an interdisciplinary character involving the synthesis of ideas from many branches of science; and (4) research involving major and expensive tools, or very large and expensive group efforts.

That persons best suited to individual research are most often found in the faculties of the colleges and universities is no accident. The diversity of the university atmosphere can react to broaden the interest of the individual and provide the intellectual tools required to associate diverse facts. But support of qualified individual effort must not be restricted to the university; such effort should be nurtured in whatever atmosphere suitable minds are found.

The growing complexity of ideas and the problems of assembly and operation of even modest experimental apparatus has brought group research ever more into the forefront. Experience shows that four to seven workers devoting their effort to a single problem appear to react together in a kind of optimum way in advancing scientific knowledge. Usually, such a group operates under the motivation of an intellectually strong leader with a number of associates each carrying part of the load. Very often such a team will require the use of large and expensive research tools operated by someone else to provide them with the means for their success. But the core of the effort is the small team—men who work together as equals in the assembly and perfection of their apparatus, and in ordering facts and ideas to achieve the final solution. The group effort in the discovery of the anti-proton or the anti-neutron, or the direct proof of the existence of the neutrino, may be cited as examples of the need for, and effectiveness of, group effort.

Then there is the direction of research toward goals involving large and expensive tools or highly organized efforts. In the study of the macrocosm, the universe, the microcosm and the atom, large and expensive tools are necessary to order and to convey the phenomena to our simple senses. Even in the study of the Earth itself, highly organized and extensive efforts of thousands of scientists over its surface are necessary to provide a scientific view of the Earth as a planet.

In the administration of research, leaders are constantly faced with the dilemma of deciding the proper division of funds between the large-scale research devices as contrasted with the individual or group research efforts. The decision to expend effort and support on large research tools must rest upon the evaluation of the contribution that the tool can make to the sum of human knowledge. Without such tools, science cannot be provided with the essential information on which even the individual research worker must depend to keep his thinking tied to reality. The recent destruction of the generality of the concept of parity has clearly emerged from the development of ideas arising from research with the great nuclear accelerators. Where this new concept will lead, that Nature discriminates between right- and left-handed motion, no one at the moment can say.

The effectiveness of the individual worker depends on a balanced progress of human thought in every field, even though some fields of research require tools that are disproportionately expensive. Without support for the sciences that require expensive apparatus or effort, the whole of science would soon become over-specialized and sterile. The problem is to achieve balance between the support of the small research worker and the provision of adequate tools required for the significant advancement of scientific progress on every front.

This problem of balance becomes especially important when progress in one science becomes noticeably limited by lack of effort in the related sciences. From a recent study on the progress of meteorology, it seems apparent that a limiting factor in the growth of meteorological science is the slower progress in our knowledge of the oceans and the absence of development of synoptic oceanography.

Perhaps critical dependence on costly scientific tools or operations may best be dramatized by citing the example of the Earth satellite. The instrumentation, launching, tracking, and data-collection involved in the satellite programme are very expensive, involving some tens of millions of dollars. Concern has been expressed that the equivalent sum of money directed toward other research objectives might be more effective. But this concern seems open to question when one examines the potentialities of the satellite as a new and fundamental scientific tool that provides a power of a new order of magnitude to science. The satellite offers the opportunity of measuring for the first time the heat balance of the Earth. The satellite can provide a knowledge of the external size distribution, density and variation of meteoric dust—particles that may conceivably provide condensation nuclei as an external environmental influence on cloud formation and rainfall. It can describe variations in the solar, ultra-violet and X-radiations from a vantage-point above the absorbing atmosphere that is influenced by such radiation and vastly extend our power for study of the Sun itself. The satellite can eventually map the complex of cloud and storm systems and their movement over the entire surface of the Earth, including 75 per cent of the area over the oceans and the polar regions that now are instrumentally inaccessible.

In addition, the satellite will acquire information concerning a whole range of other scientific phenomena such as the primary cosmic ray spectrum, before it enters the atmosphere, and the magnetic field of the Earth in its extensions and distortions in space. As a new major tool in science, the very large expenditures required for the erection of the satellite may turn whole areas of individual or group research into entirely new and more productive avenues.

Turning to the problem of support for research, Berkner suggested that the most desirable form should originate from a diversity of sources. The problem is to encourage and justify support from the wide range of agencies which in our society benefit from the advancement of scientific thought. First of all, the universities themselves have a responsibility to provide support for research activities within their bounds. Second, a great growth of industrial support must be generated. Ultimately something like one per cent of the gross output of American industry should be made available to the universities and related academic activities for pure research as distinguished from their educational effort. In addition to the support of their own large research laboratories that both contribute to, and capitalize on, scientific progress, industry must carry an additional burden of responsibility to make possible the growth of fundamental thought that can only emerge from the university.

There was a time in human history when the motivation for scientific research was purely the curiosity of man and his aspiration to know the nature of things around. To-day there is another compelling challenge that motivates research—as society has acquired the benefits of science, it has become wholly dependent on the continual production of new benefits from science so that the motivation for research is no longer wholly academic.

At the present time, as nearly as can be estimated, the money expended in the United States for fundamental research based on studies is approximately two hundred million dollars annually from all sources, government and private. This is approximately five-hundredths of one per cent of the gross national product. In the future the economic development of the country must depend more and more upon new resources and capital developed from man's brain rather than from his brawn. Perhaps on this idea one can estimate that it is not unreasonable that the total national fundamental research effort should be pushed to an annual level of perhaps one half of one per cent of the gross national product.

THE PHYSICAL SOCIETY

At the annual general meeting of the Physical Society, held in London at the offices of the Society on May 30, the reports of the Council and of the honorary treasurer and the accounts and balance sheet for 1957 were presented and adopted, and the officers and Council for 1958–59 were elected (see *Nature*, 181, 1640; 1958). Immediately prior to the annual meeting an extraordinary general meeting was held to give approval to an alteration of the rules of the Society whereby the status of honorary exhibition secretary was raised to that of honorary secretary of the Society. In the newly elected council Mr. A. G. Peacock becomes the first honorary secretary (exhibition), joining the two other honorary secretaries, Dr. H. H. Hopkins (papers) and Dr. C. G. Wynne (business), who were re-elected.

The accounts show that the total income of the Society was £49,075, comprising £5,747 from membership subscription, £25,969 from publications, and £17,359 from the forty-first exhibition of scientific instruments and apparatus which was held during March 25–28, 1957, in the Old and New Halls of the Royal Horticultural Society, London. The excess of income over expenditure, merely £20, was very much less than in recent years, and two reasons are advanced for this reduction—a decrease of £1,000 in the annual grant received from the Royal Society for publications and an abnormal increase, both in size and in the number of copies printed, of the 1957 issue (Vol. 20) of the *Reports on Progress in Physics* published by the Physical Society. It is expected that the Council's decision to increase the price of the Society's publications when sold to the general public will restore a more favourable financial position during 1958.

The Council's report refers only briefly to the activities of the Society and of its four specialist groups—Colour, Optical, Low Temperature and Acoustics—but it mentions that a more detailed list of the conferences, meetings and lectures which have been held is given in the 1957 Yearbook of the Society (*Nature*, 181, 1046; 1958). This list, however, covers the period September 1956–July 1957 and not the calendar year 1957, which is the period covered by the annual report.

In the section of the annual report dealing with the Society's publications it is stated that greater promptitude in publication of the *Proceedings* was achieved during the period under review. 199 papers, 68 research notes and 27 letters to the editor were published; 58 manuscripts were either rejected or withdrawn. It was decided to discontinue at the end of 1957 the sub-division of the *Proceedings* into the two sections, Parts *A* and *B*. Vol. 20 of the *Reports on Progress in Physics*, which was published during the summer, contains, in addition to nine reports, a cumulative index to the contents of Vols. 16–20, and both the index and individual reports are also available for purchase as separate pamphlets. No special publications or conference reports were issued during the year. S. Weintroub

FOOD ADDITIVES

The Joint FAO/WHO Expert Committee on Food Additives has now published its second report*. Whereas the first one dealt with general principles governing the use of such additives, this second report gives guidance on "Procedures for the testing of intentional food additives to establish their safety for use".

The use of food additives has greatly increased in recent years, and little is known about the health hazards which may result from their continual ingestion, either singly or in the mixture which a modern diet now provides. The Committee envisages the need for long-term animal feeding experiments since "the toxic or other biological effects of the test material cannot be predicted solely from a consideration of its chemical and physical properties". This is partly because a deleterious effect might be due not to the additive directly but to its effect on some other substance in the food or to changes consequent upon cooking, long storage, etc. Moreover, the same substance might exert a different effect when added to different foods, when fed to different age-groups, or when used in the diets of communities with different disease patterns. Since the hazard to the consumer will result from the total number of additives in the diet eaten, it is also necessary to have up-to-date information about the diets used by different groups within the community on whose behalf legislation is envisaged. The resultant effect of interplay between different additives may well vary with variations in the mixture of foods used to form the basic diet.

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* Procedures for the Testing of Intentional Food Additives to establish their Safety for Use. Second Report of the Joint FAO/WHO Expert Committee on Food Additives. World Health Organization Technical Report Series No. 144. (Geneva, 1958.)

The Committee points out that the procedures outlined in the report require all the resources of a well-equipped laboratory and animal house, and an adequately trained staff "having access to current scientific literature over a wide field", and the warning is given that "the provision of such facilities on an adequate scale is very costly". Not all Governments could afford the outlay even if they had competent staff available for the work: yet the use of such additives without prior testing exposes the public to new risks of unknown magnitude, and protective legislation is undoubtedly required. Perhaps the difficulties involved will result in a reduction of the number of additives now used and a more emphatic application of the Committee's principle that "when a new food additive is proposed for use, clear evidence must be available to show that benefits to the consumer will ensue". The Committee also expresses the opinion that "no proved carcinogen should be considered suitable for use . . . in any amount".

M. W. GRANT

A NEW TYPE OF TITANIUM GETTER PUMP

By L. HOLLAND, L. LAURENSON and J. T. HOLDEN

Research Laboratory, Edwards High Vacuum, Ltd.

HERB *et al.*[1] have described a novel vacuum pump in which gas is absorbed by a freshly evaporated titanium film. Gases which were not easily absorbed by the getter were removed by ion pumping and such combined devices have been termed 'evapor-ion' pumps. The evaporation of titanium is rendered difficult because at the evaporation temperature the molten metal reacts readily with refractory materials. In the pump described by Davis and Divatia[2] titanium wire was fed on an electron-bombarded anode made of carbon which was replaced in later experiments by a tantalum–tungsten alloy. The useful life of these materials is limited, and the feed rate of the wire must be restricted to some 5 mgm./min. It is natural, therefore, that attention should be given to designs of vapour sources in which refractory supports are avoided, and some recent reports[5,6] of work in this field prompt us to describe our experiences.

Holland[3] has described an evaporation source for general use in which reaction between the evaporant and the support material may be avoided by directly bombarding the end of a wire fed into an electron beam. We have used this method for evaporating titanium and found that a molten globule may be easily formed on the end of a wire fed downward, but that it is difficult to attain the high temperature required for rapid evaporation because the globule is taken out of the region of intense electron bombardment by melting back along the wire. Thus either rapid feeding of the wire or increase in the electron intensity only results in the enlargement of the metal globule up to a critical diameter while its temperature remains constant at the melting point (about 1,660° C.). Using a feed wire 1 mm. in diameter, molten titanium droplets can be supported up to a maximum diameter of 5 mm., which give an evaporation rate of 15 mgm./min. at 1,660° C.

We have observed[4] that a globule of titanium may be raised to a very high temperature if the wire is fed downwards through a water-cooled copper block into the electron beam and the metal is allowed to melt back and contact the cooled block. A hemispherical globule is then formed which hangs from a frozen zone adhering to the cooled surface. Should the globule become detached from the feed wire, it remains suspended from the cooled block, and the size of the droplet is limited only by the area of the cooled zone. Thus we have supported titanium hemispheres up to 5 mm. in radius on a block 1 cm. in diameter, while the tip of the molten droplet was raised to a temperature of about 2,000° C.

We have found that it is difficult to cool the feed wire in the guide nozzle, and the exit of a tubular nozzle may become blocked by the titanium melting back and freezing in the tube. To avoid this we have fed the wire down an inclined plane so that it is located at the edge of the anode block without being laterally restricted (Fig. 1). If the wire feed is obstructed when the metal globule sticks to the anode then the wire may bend sideways and continue to enter the beam, in which case more than one globule may be formed. The life-time of the vapour source is solely dependent on that of the cathode filament which is eroded by ion bombardment.

Using such a vapour source inside a water-cooled vessel 18 in. in diameter and feeding wire 40/1,000 in.

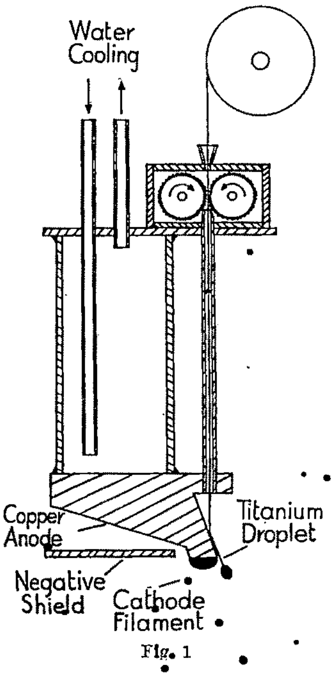

Fig. 1

in diameter we have achieved evaporation rates of up to 250 mgm./min. at a power input of 1·25 kV. and 4 amp. Evaporating at a rate of 100 mgm./min. at 1 kV. and 1·2 amp, we have achieved pumping speeds for air of some 1,000 l./sec. at 10^{-5} mm. mercury. A pump similar to that described was shown at the Physical Society Exhibition in 1958.

Recently, Milleron[5] has described a titanium vapour source in which a molten bead is formed on the end of a wire fed upwards into an electron beam. In our early experiments we used a similar apparatus and found that the viscosity of the metal was greatly reduced as the evaporation temperature rose above the melting point so that the liquid metal ran backwards under gravity and blocked the entry tube.

Winogradoff[6] has described a titanium vapour source in which wire is fed upwards on to the molten tip of a molybdenum rod which is heated by electron bombardment. We have found that it is very difficult to transfer metal to a heated surface in this way because either the feed tube obstructs the emitted vapour or the feed wire melts backwards when traversing the electron-bombardment zone.

If the thermionic cathode of the vapour source bombarded with electrons is grounded, the metal condensing wall of the getter pump may operate as a cold cathode for a glow discharge at pressures above 10^{-4} mm. mercury. Positive-ion bombardment removes absorbed gas from the condensed metal and reduces the electron-bombardment current flowing to the evaporant. We have avoided this by using a cathode heater transformer which is insulated from earth potential at high gas pressures. We have also found that with the condensing wall at a positive potential the pump may be degassed by electron bombardment using an auxiliary cathode[4]. A typical operating cycle of our pump is as follows: the pump chamber is first degassed by electron bombardment and, after the pressure has been reduced to 5×10^{-4} mm. mercury, using a two-stage rotary pump, evaporation is commenced. When the pressure has fallen, due to gettering to 10^{-5} mm. mercury, the cathode is grounded so that the positive ions formed by electrons colliding with gas molecules may be transported to the chamber walls. The combined action of the 'evapor-ion' pump using titanium with a hydrogen content of 0·008 per cent by weight gives an ultimate of 10^{-6} mm. mercury.

Our thanks are due to Mr. R. L. Simpkins for his valued help during the construction of the titanium pump and to Mr. A. S. D. Barrett, technical director of Edwards High Vacuum, Ltd., for permission to publish this communication.

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THREE VARIETIES OF HUMAN HÆMOGLOBIN *D*

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AND

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THE list of variants of human hæmoglobin is already an imposing one. Twenty-two are listed in a recent publication[1], many of which have been shown to be genetically determined. Since the identification of hæmoglobin types is ordinarily based upon properties such as electrophoretic mobility, solubility, and chromatographic behaviour on ion-exchange columns it might be expected that the application of more sensitive methods would reveal an even greater multiplicity of forms. Our results with three different hæmoglobin *D* samples confirm this.

Hæmoglobin *D* was discovered by Itano in 1951[2] in an American 'white' family. It has the same electrophoretic mobility[2,3] as hæmoglobin *S* and behaves similarly during ion-exchange chromatography[4]. The two hæmoglobins differ, however, in the solubility of the reduced form[2,3,5]. Only hæmoglobin *S* possesses the low solubility of the reduced form which causes sickling of the erythrocytes.

Hæmoglobin *D* has also been found in an English family with Austrian and Spanish connexions[6] and in a Mulatto family in Britain[7] where it could be traced to the non-Negro mother. There have been records of its occurrence in Algerian Muslims[8], and 35 instances have by now been seen among 5,610 Muslims of mixed origin examined in Algiers (Cabannes, R., personal communication). Studies from Missouri and North Carolina showed an incidence of 0·4 per cent in American Negroes[9]. Large-scale surveys in Africa south of the Sahara have failed to discover hæmoglobin *D* in that area, with one exception where, however, the electrophoretic mobility at alkaline *p*H of the hæmoglobin *D* described[10] was slightly faster than that of *S*. In Asia, one example was discovered in a Persian family[11], and one family with hæmoglobin *D* was found in the course of a survey of 400 unrelated Turks[12]. We have recently seen hæmoglobin in a Turkish Cypriot family.

In contrast to these sporadic findings, hæmoglobin *D* has been found in two Indian populations—the Sikhs and the Gujeratis—at an incidence of 1·8 and 1·1 per cent, respectively[13,14].

We have examined three samples of hæmoglobin *D* coming respectively from a Turkish Cypriot (α), from a Gujerati Indian (β) and from a Sikh (γ), and have found, in fact, that each carries a chemical change in a different part of the hæmoglobin molecule. In all three instances no sickling of the intact red cells was seen when they were reduced with 2 per cent

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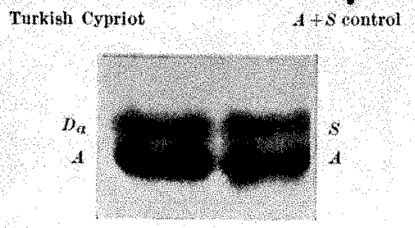

Fig. 1*a*. Comparison by filter paper electrophoresis at alkaline *p*H of the hæmoglobin of the Turkish Cypriot ($A+D_a$) with a hæmoglobin $A+S$ control. D_a and S are indistinguishable by this method

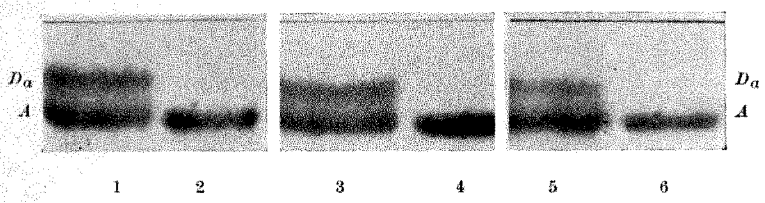

Fig. 1*b*. The hæmoglobins of the family of the Turkish Cypriot (5). Paper electrophoresis at alkaline *p*H. The father and one sister are also hæmoglobin *D* trait carriers. The mother, one sister and one brother possess hæmoglobin *A* only. 1, Father; 2, mother; 3 and 4, sisters; 5, propositus; 6, brother (non-identical twin)

sodium metabisulphite, thus showing that no hæmoglobin *S* was present. On electrophoresis of the purified hæmoglobin solutions, the first two samples resolved into two fractions with the mobilities of hæmoglobin *A* and *S* or *D*, respectively (Figs. 1 and 2), and the third consisted of a single component[15] with the electrophoretic properties of *S* or *D*. Identical results were obtained with ion exchange chromatography (Amberlite *IRC*50). The presence of hæmoglobin *S* could be excluded in all three samples by Itano's solubility test[5], where reduced hæmoglobin *S* and mixtures of reduced hæmoglobins *AS* or *SD* all show a solubility below 5 gm./l. of Itano's 2·24 *M* phosphate buffer at 25°. The ferrohæmoglobins of the Turkish Cypriot (AD_a), the Gujerati (AD_β) and of the Sikh (D_γ) all showed complete and ready solubility at this concentration and temperature.

The specimen from the Sikh (D_γ) could be used without further purification. Hæmoglobins D_a and D_β were isolated from their mixtures with *A* by paper electrophoresis in 0·06 *M* veronal buffer at *p*H 8·6[16]. Each hæmoglobin was denatured by heat and digested with trypsin, as previously described[16,17], to give a mixture of peptides for examination by 'fingerprinting'. The distinction between the three hæmoglobins *D* could be seen readily by one-dimensional electrophoresis[6] as shown in Fig. 3.

In hæmoglobin D_a peptide 23 (see ref. 16) has disappeared, and in hæmoglobin D_β peptide 26 is missing, whereas in D_γ both these peptides are present.

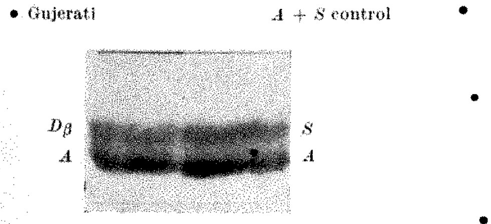

Fig. 2. Comparison by filter paper electrophoresis at alkaline *p*H of the hæmoglobin of the Gujerati ($A+D_\beta$) with a hæmoglobin $A+S$ control. D_β and S are indistinguishable

Further analysis by two-dimensional 'fingerprints' indicated that in hæmoglobins D_a and D_β new peptides had appeared in the band of the neutral peptides, and that in D_γ one of the normal peptides (containing tyrosine) seemed to have disappeared from the neutral band. The exhaustive examination necessary for the precise identification of all changes in amino-acid sequence, as done[16-19] for hæmoglobins *S* and *C*, has not yet been carried out. Enough has been learned, however, to support the conclusion that the three hæmoglobin *D* samples are distinct proteins; also some, if not all, the chemical changes involved have been indicated.

It was particularly surprising that there was a difference between the two hæmoglobins from the two Indians. Though the Gujeratis and the Sikhs represent rather different types of Indian populations, one might have expected that the 1–2 per cent incidence of hæmoglobin *D* would prove a link rather than differentiate between the two. It has been somewhat of a puzzle that surveys of other Indian populations had so far not resulted in the finding of hæmoglobin *D* among them. The present observation that the two hæmoglobins *D* of the Gujerati and the Sikh are the result of distinct mutations would explain the patchy distribution of hæmoglobin *D* in India.

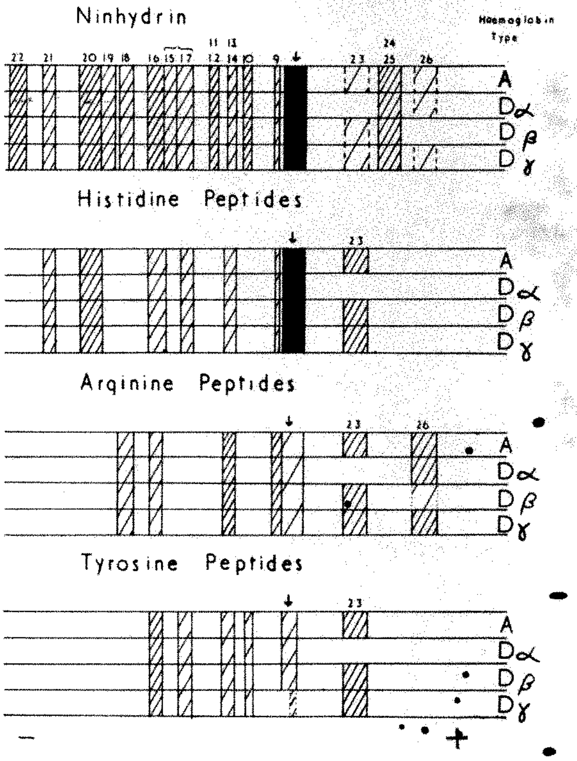

Fig. 3. Comparison by one-dimensional paper electrophoresis[6] of tryptic digests of hæmoglobins A, D_a, D_β, D_γ at *p*H 6·4. Peptides numbers 23 and 26 (see ref. 16) give only weak colours with ninhydrin, even after heating. Both hæmoglobins D_a and D_β by reason of the isolation procedure contain small amounts of hæmoglobin *A*. The colour reaction specific for various amino-acids were carried out as described in ref. 20 under the following authors: ninhydrin—Toennies, 1951; histidine—Karler, 1952, Baldridge, 1953; arginine—Jepson, 1953; tyrosine—Acher, 1952. Arrows indicate neutral points

It is clear that considerable caution will have to be applied to the anthropological interpretation of the distribution of characters such as hæmoglobin D which may be the result of entirely different mutations.

In hæmoglobin S, mutation has been shown to have resulted in the replacement of a negatively charged glutamic acid residue by uncharged valine[16,17]. The similar electrophoretic properties of hæmoglobin D could result from the replacement of any negatively charged amino-acid residue by a neutral one, or from the replacement of any of the many neutral amino-acids of the globin molecule by a positively charged arginine or lysine. In general, however, such altered hæmoglobins might be expected to differ from hæmoglobin S in not having an abnormally low solubility.

In hæmoglobin C the same glutamic acid residue as in hæmoglobin S was found to be affected[19], in that case being changed to lysine. It is important to note, therefore, that mutational alterations are not restricted to that particular location, but may arise, as in hæmoglobins D_α, D_β and D_γ, in various parts of the molecule.

The assistance of Mrs. Rita Fishpool is gratefully acknowledged.

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AUTORADIOGRAPHY OF FUNGI THROUGH A LAYER OF SOIL AND IN AGAR CULTURE

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AUTORADIOGRAPHY has become a standard tool of industrial and, to a large extent, of biological research. In the field of mycology it has so far been utilized comparatively little. It is the purpose of this article to describe a few applications of this technique to the study of fungal physiology at the Grassland Research Institute, Hurley.

The subject of autoradiography has been well reviewed by Boyd[1]. He defines it as the "production of a two- or three-dimensional image on a photographic film or plate by radio-active radiation".

In biological research, nuclides emitting β-rays of low energy are most frequently used for autoradiography. We have used β-radiation, but in addition, investigations have been made to exploit by autoradiography the characteristic of deep penetration by γ-photons in order to locate the position of a radio-active fungus inoculum buried in soil. In 1957, Grossbard and Stranks[2] published a preliminary note on their attempt to record the growth of fungi directly in the soil, that is, *in situ*, by labelling the inoculum, locating its position and tracing its growth by means of a scintillation counter. In view of the high energy of γ-photons and consequently poor resolution, because of absorption and back scatter by soil particles, a well-defined and true image of the specimen could not be expected. It was, however, assumed that the possibility of locating a fungal colony in the soil, by so simple a technique as autoradiography, might prove to be a useful research tool even if only a mere shadow could be obtained.

The fungi used in the work described in this paper were: *Armillaria mellea* (Vahl ex Fries) Quél Herb. I.M.I. 61755, *Fusarium culmorum* (W. G. Smith) Sacc. Herb. I.M.I. 35099, *Phycomyces blakesleeanus* Burgeff Herb. I.M.I. 44142, *Phytophthora cactorum* (Leb. and Cohn) Schroet. Herb. I.M.I. 62471, *Rhizoctonia solani* Kühn, kindly supplied by Dr. S. D. Garrett, *Rhizopus stolonifer* (Ehrenb. ex Fr.) Lind. Herb. I.M.I. 42844, and *Verticillium albo-atrum* (Reinke and Berth.) Herb. I.M.I. 62131[1]. The nuclides acting as tracers were the γ-ray emitters caesium-137 and cobalt-60. The fungi were grown in either a nutrient broth or agar, containing the nuclides which they readily absorbed. In broth cultures the mat was harvested and washed with water over a sintered glass filter until the filtrate showed no more activity. In the case of some fungi, especially *P. cactorum*, the tracers continued to be leached out on prolonged washing, but in others a fair proportion of the nuclides was retained permanently in the mycelium. Agar cultures were not washed, and a number of disks or squares served as the inoculum. The mycelium was mixed with a small quantity of soil or sand/oatmeal and buried at various depths in a glass or aluminium dish containing autoclaved soil or placed at the top end of a column of soil contained in a glass tube, that is, a so-called growth tube.

The method of autoradiography used consisted in placing an envelope-packed Ilford X-ray film Industrial *B* beneath and on top of the dish containing soil and the radio-active fungus, or below the growth tube; the film rested on a lead sheet 1/16 in. thick. This lead screen is essential since the photographic effect of γ-photons is, to a large extent, a result of the emission of secondary electrons from lead. Kodak

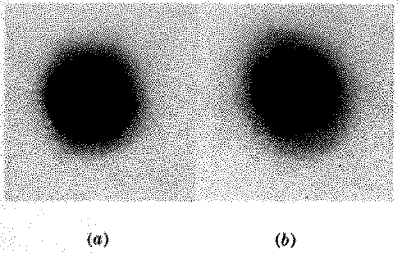
(a) (b)

Fig. 1. *Armillaria mellea* (cobalt-60). A disk of an agar culture was buried in soil, 1 cm. from the top. Total depth of soil in dish was 5 cm. (*a*) Autoradiogram through lid and 1 cm. of soil, and (*b*) through bottom of dish and 4 cm. of soil. Exposed for 26 days. Note that image in (*b*) is still clearly visible but intensity is much lower and the outlines are blurred

X-ray intensifying screens were tested in a few experiments but no improvement was observed. The preparations were exposed for 14–28 days depending on the activities of the nuclides, the depth of the soil layer and whether an aluminium or glass dish had been used, aluminium absorbing a greater proportion of the radiation than does glass.

Images obtained by this method are depicted in Fig. 1 (*a* and *b*); the experimental conditions are given in the legend.

Whatever the shape of the inoculum, whether it was buried in soil, placed on top of a soil layer or at one end of a soil column, the image in each case was a circular area of blackening, revealing no details of morphology such as the rhizomorphs present in the culture of *A. mellea*. The diameter and the intensity seemed to decrease with an increase in the depth of the soil layer through which the rays had to travel. As is generally the case in autoradiography, concentration of the nuclide and duration of exposure influenced the degree of blackening. Experiments are in progress to establish these correlations on a quantitative basis, taking into account density and moisture content of the soil as well as other factors normally affecting the absorption of radiation. The actual position of the fungus inoculum could be located with some accuracy.

It was possible to obtain an image from inocula containing very low concentrations of the tracer. For example, *V. albo-atrum* was grown in a Dox solution containing caesium-137. The mat, after thorough washing, contained about 3·0 μc. of the tracer. When placed on top of a layer of soil 1½ cm. deep in a Petri-dish the autoradiogram, through the bottom of the dish, produced an image similar to that in Fig. 1*b*. This is an important point, since one of the applications of this method envisaged is the study of the growth of fungi directly in the soil. Even if the original inoculum were to contain a very large concentration of the tracer the outward growth of hyphae would bring about considerable dilution and we might be left with very low activities. A method of autoradiography capable of recording such low activities must be devised. At present two great difficulties will have to be solved before the technique can be used to its full extent for growth studies. First, it has not so far been possible to demonstrate translocation of caesium-137 and cobalt-60 in the soil by the fungi tested by Grossbard and Stranks[2]. On the other hand, there is evidence that, at least in agar cultures, these nuclides were transported in the case of *P. blakesleeanus*, *R. stolonifer* and *P. cactorum*. Second, the long time of exposure necessary to produce an image reduces the value of this method for growth studies. However, as this technique is only in its initial stage of development and is still very crude, it is hoped that ways will be found to reduce the exposure time. Once the technique is perfected it should find various applications especially in plant pathology and, perhaps, also in root-growth studies.

The method described above is primarily based on the effect of gamma-radiation. Both caesium-137 and cobalt-60 emit beta particles in addition to γ-photons. Thus some of the standard techniques of autoradiography which utilize mainly β-radiations could be adapted for our purpose, namely, apposition on a non-screen X-ray film and the stripping film technique as devised by Pelc[3]. Both proved valuable in studies on translocation in fungi[4]. Fig. 2 illustrates an example of apposition on an X-ray film. Fragments of sporangiophores of *R. stolonifer* were removed 2–3 cm. above a substrate containing cobalt-60. The material was teased out in water, allowed to dry on a slide and wrapped in 'Cellophane'. The slide was placed on an Ilford X-ray film Industrial *B*, with the fungus facing the emulsion, wrapped in a lightproof envelope and exposed for 28 days. This long exposure was necessary because of the very small concentration of the tracer, which could barely be detected by a scintillation counter. Exposure could be reduced to 6 days or less in other preparations. As can be seen in Fig. 2 the individual fragments of the sporangiophores and the sporangia are easily discerned. While the tracer had been leached, forming black irregular areas, it is clear that cobalt-60 was translocated through the sporangiophores and accumulated in the sporangia.

The stripping film technique was used for microscopic observations of fungal hyphae. In order to demonstrate absorption and accumulation of a tracer by hyphae submerged in a radioactive substrate, very thin sections of agar cultures of *R. solani* containing cobalt-60 were placed on slides and allowed to dry in order to obtain a thin specimen by dehydration of the agar. The preparations were coated with sections of strippable film (Kodak scientific plate *A.R.*10) as described by Pelc[3], and after exposure for 6–14 days developed in the normal manner. They were photographed unstained under an optical microscope (Fig. 3). The background showed considerable grain

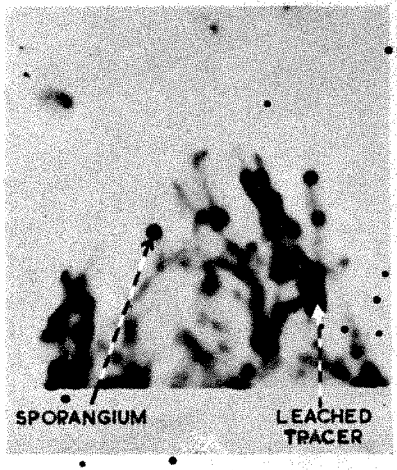

Fig. 2. *Rhizopus stolonifer* (cobalt-60). Autoradiogram of fragments of sporangiophores by apposition on X-ray film. Exposed for 28 days. Note accumulation of tracer in the sporangia. (× 3)

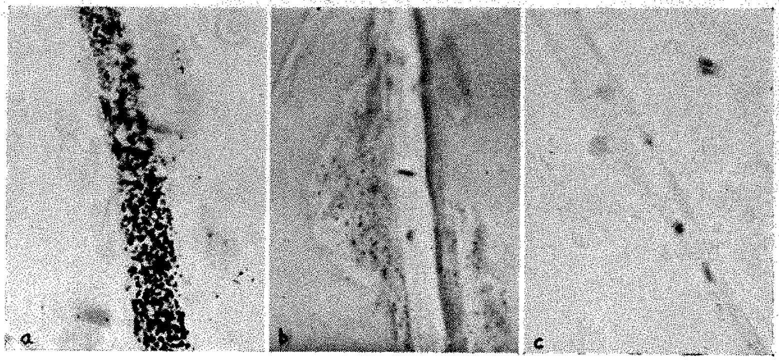

Fig. 4. *Phytophthora cactorum* (cobalt-60). Photomicrograph of autoradiogram of hyphae grown over a coverslip placed on the surface of a substrate containing cobalt-60. (*a*) Hyphal content intact; (*b*) content oozing out; (*c*) empty hypha. Exposed for twelve days. Note the density of grains in (*a*) and their complete absence in (*c*). (×1,340)

density, due to the thin layer of radioactive agar still adhering to the slide. The concentration of grains in the hyphae was considerably greater, suggesting accumulation of the tracer within. In order to study translocation into the aerial mycelium, aerial hyphae of various fungi were removed and teased out in water. An autoradiogram was prepared as before. Here, a considerable difficulty was encountered common in preparation of biological material for autoradiography; namely, leaching of the tracer. Robson (personal communication), who applied Canny's[5] modification of the stripping film technique in her work on the sulphur metabolism of fungi, has overcome this by freeze-drying and embedding the specimen in wax under vacuum. The hyphae were afterwards sectioned. While this method was being studied in our laboratory, attempts were made to prevent leaching of cobalt-60 by converting it into the insoluble sulphide. After the culture had been made alkaline a gentle stream of hydrogen sulphide was bubbled through. However, although the tracer was precipitated, there were so many side-effects and artefacts that interpretation became difficult. A useful method was devised by Barton (personal communication). The radioactive agar was inoculated with the fungus under study and then coverslips 38 × 22 mm. were placed so as to just touch the surface of the agar. On incubation some fungi such as *P. cactorum*, *R. solani* and *F. culmorum* grew over the cover slips forming a thin mat, sometimes of only a few hyphae. This made an ideal preparation for the stripping film technique, which requires a thin specimen. The need for teasing out was dispensed with. By careful removing of the coverslip a minimum disturbance of the hyphae was achieved. The coverslips were cemented to an ordinary microscope slide and autoradiograms prepared. We have found that the rapid immersion into a water-bath in order to lift up the sections of strippable film, if followed by rapid drying in a tower (designed for this purpose at Hurley by Barton), did not give rise to any appreciable leaching of the tracer. Fig. 4 (*a* and *c*) shows autoradiograms prepared by this method from a sand/oatmeal culture of *P. cactorum* containing cobalt-60 of very low activity. The preparations were photographed unstained under a phase-contrast microscope. Fig. 4*a* depicts a hyphal section with its content intact and a considerable density of silver grains as a result of the concentration of the tracer; in 4*b* the hyphal content seems to have oozed out through a rupture in the cell wall, apparently carrying with it the tracer; in (*c*) we see an empty hypha, that is, the mere cell wall and no silver grains at all. These observations would suggest that cobalt-60 is transported by protoplasmic flow rather than held by the cell wall. Though further indications supporting this hypothesis have been obtained with, for example, *P. blakesleeanus* by Grossbard and Stranks[4] a great deal more experimental work is required for confirmation of a conclusion of such fundamental importance. These experiments, however, illustrate the potentialities of the stripping film technique and autoradiography in general in fungal physiology. Another interesting application, of the stripping film technique, was reported recently by Staples and Ledbetter[6] in their studies on the distribution of tritium-labelled glycine in rust-infected leaves.

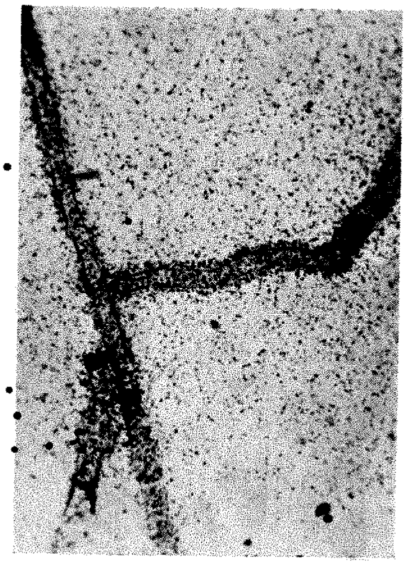

Fig. 3. *Rhizoctonia solani* (cobalt-60). Photomicrograph of autoradiogram of mycelium submerged in agar containing cobalt-60. Note larger grain density within hyphæ. Exposed for 14 days. (×340)

This article outlines but a few applications of autoradiography. Other methods described in the literature may be adapted as useful tools for the study of mycology and plant pathology.

My sincerest thanks are due to Dr. William Davies for his interest in this work, for the encouragement and guidance he gave me and for providing me with facilities to carry on these studies, and also to Mr. G. E. Barton for his valuable collaboration and technical assistance.

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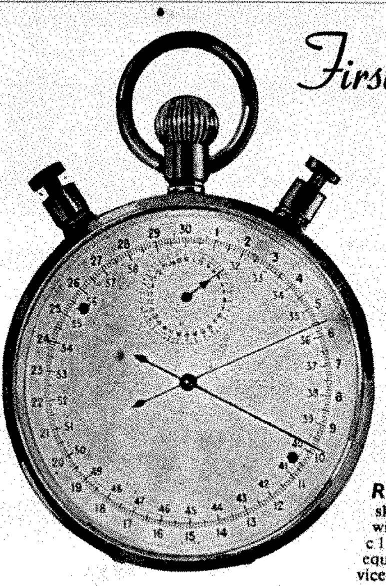

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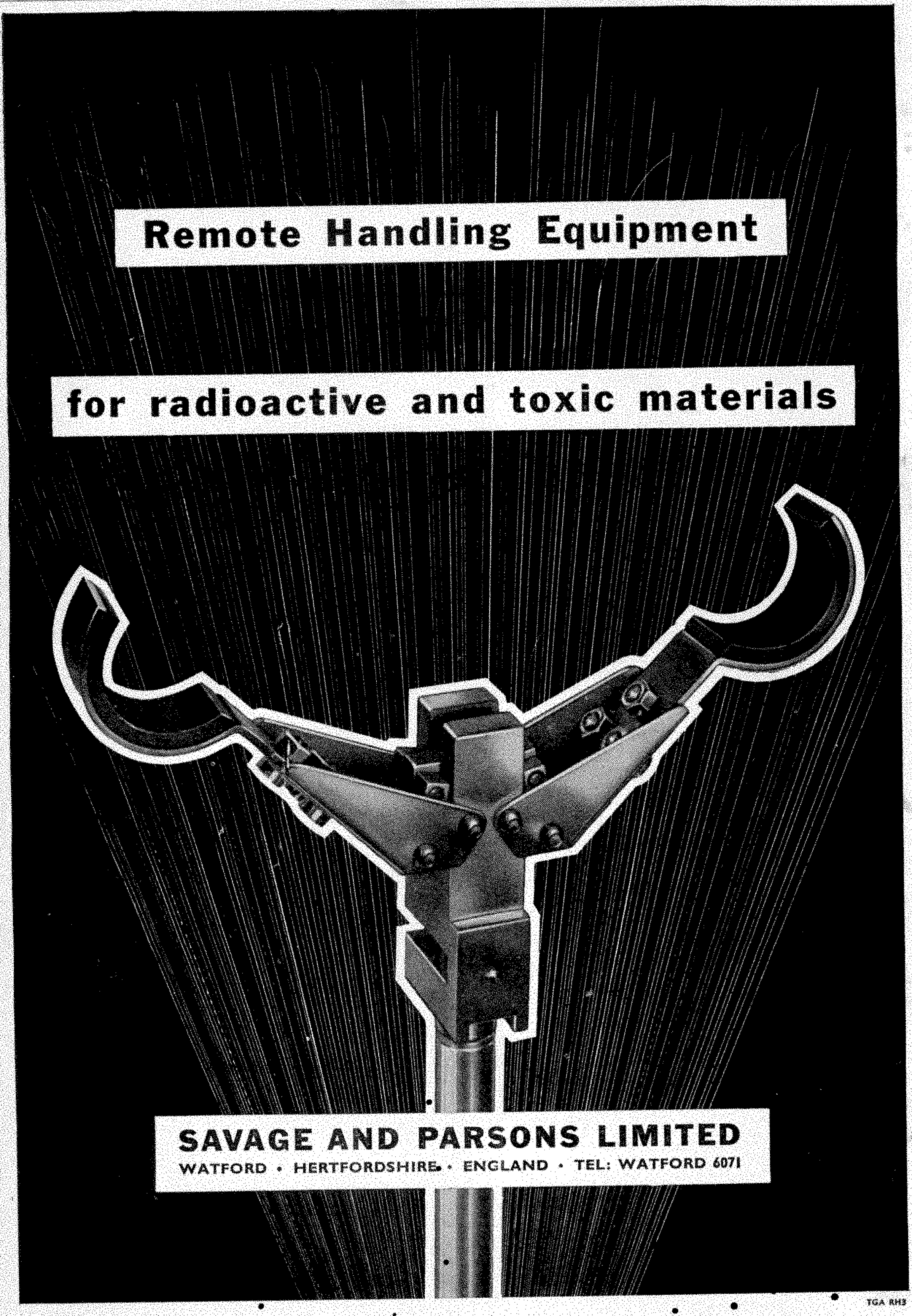

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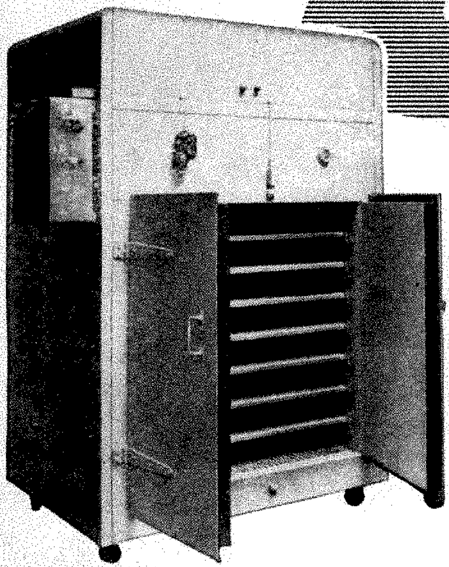

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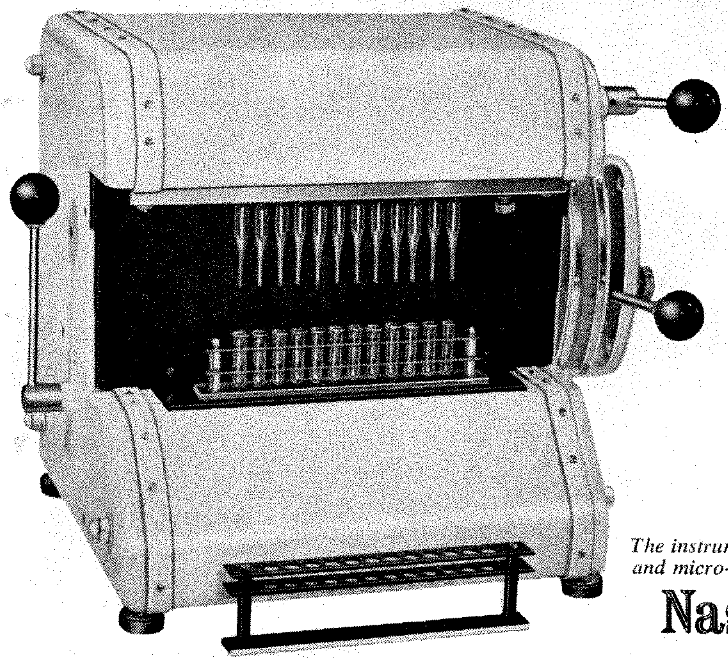

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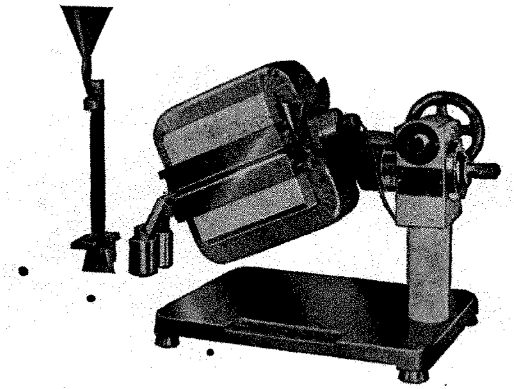

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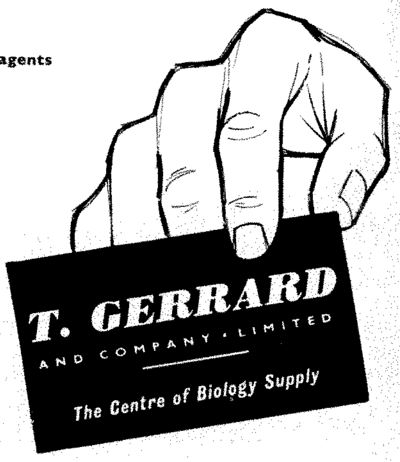

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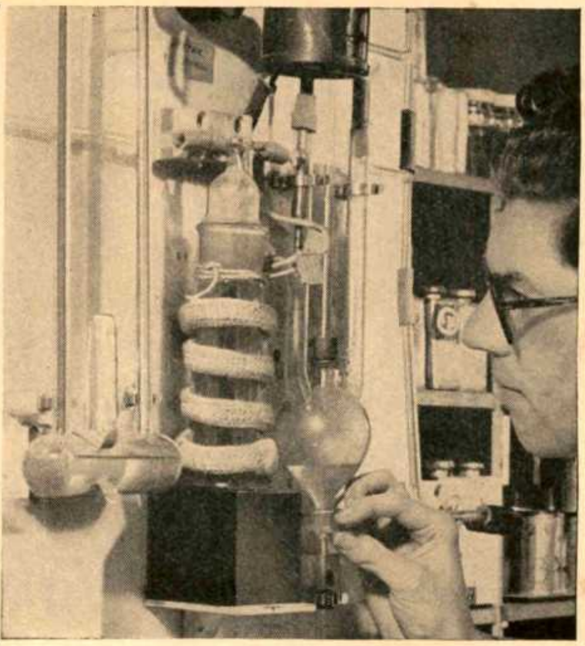

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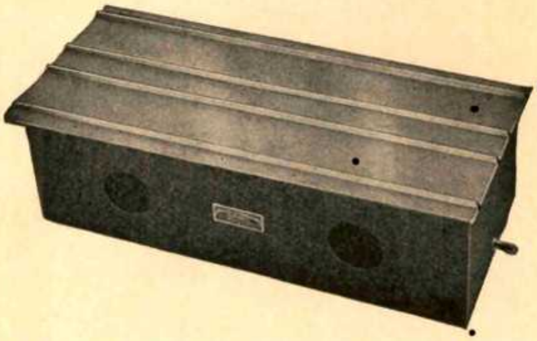

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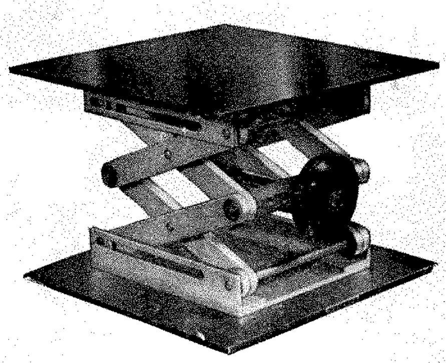

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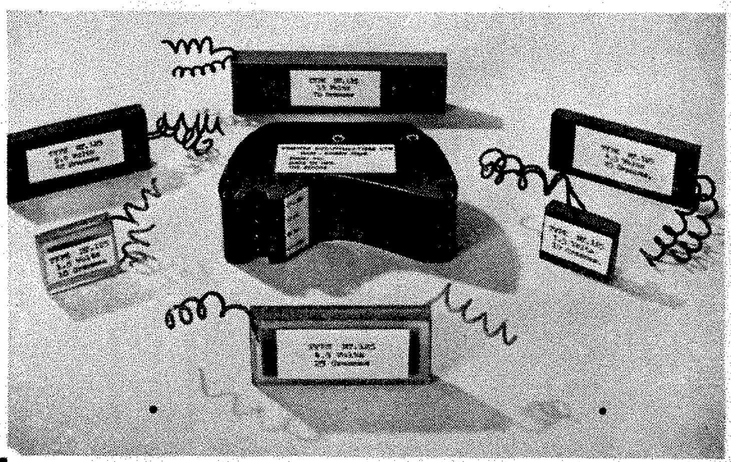

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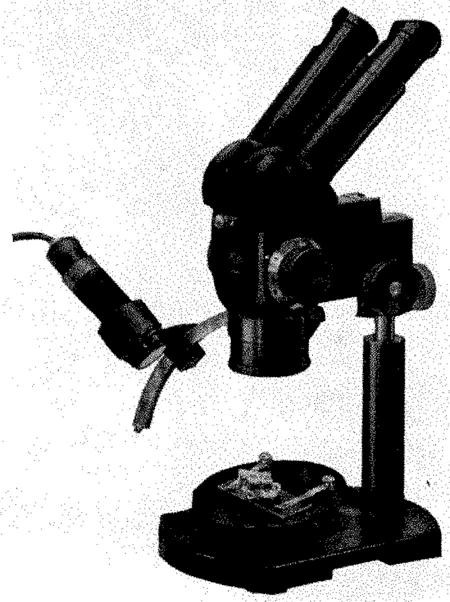

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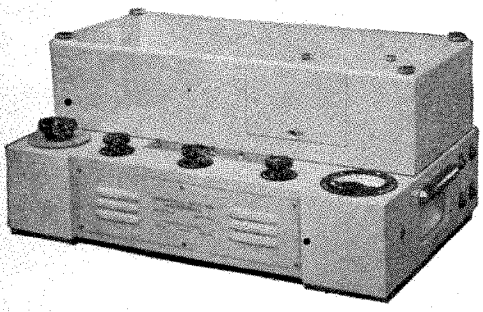

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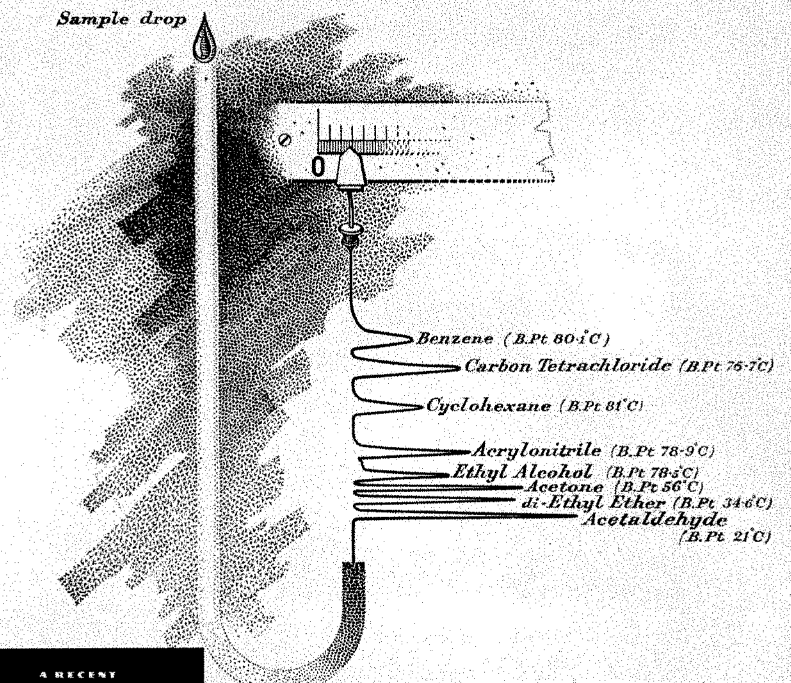
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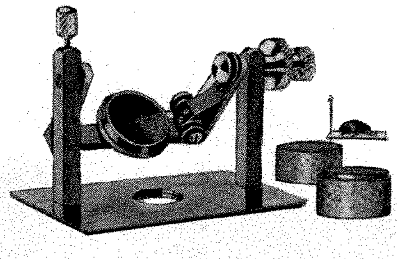

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PUPIL UNREST: AN EXAMPLE OF NOISE IN A BIOLOGICAL SERVOMECHANISM

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THE pupil of the human eye continuously undergoes small fluctuations in area even in steady illumination. These movements may be readily seen on close inspection. We considered it worth-while to investigate this pupil unrest as an example of noise in a biological system. We have therefore measured and described the phenomenon, performed experiments to decide between possible mechanisms for its production, and finally considered its possible function.

Description of the pupil unrest. One-minute samples of pupil area fluctuations were recorded. The power spectrum of a typical record is shown in Fig. 1. The power spectra are unreliable below 0·05 c./s. due to the short length of the time functions, and above 2 c./s. because the sampling rate limits the significance of the data. The autocorrelation function and the power spectra both show that the major component of the pupil unrest is random noise in the frequency-range 0·05–0·3 c./s. In the region 0·75–2·5 c./s. all three power spectra we have obtained show a general slope of 36 decibels per octave, with a corner frequency near 0·5 c./s. One power spectrum obtained from a time function of pupil diameter fluctuations showed the same corner frequency and an 18 decibel per octave slope. Power spectra of diameter fluctuation should have half the slope of area fluctuation.

The power spectra in the frequency-range 0·5–2 c./s. show an irregular distribution of power with frequency, which can be seen in the log–log plot of Fig. 1. Both the time functions and the autocorrelation functions have features which suggest the existence of coherent signals at approximately 2 c./s. However, study of the amplitude of these features in the autocorrelation functions and the power spectra show that if such signals exist they represent less than 5 per cent of the root-mean-square value of the time function.

The origin of pupil unrest. It is possible to make some deductions about the origin of the pupil unrest from information already known about the pupil light reflex, from the new results presented, and from the results of certain critical experiments described below.

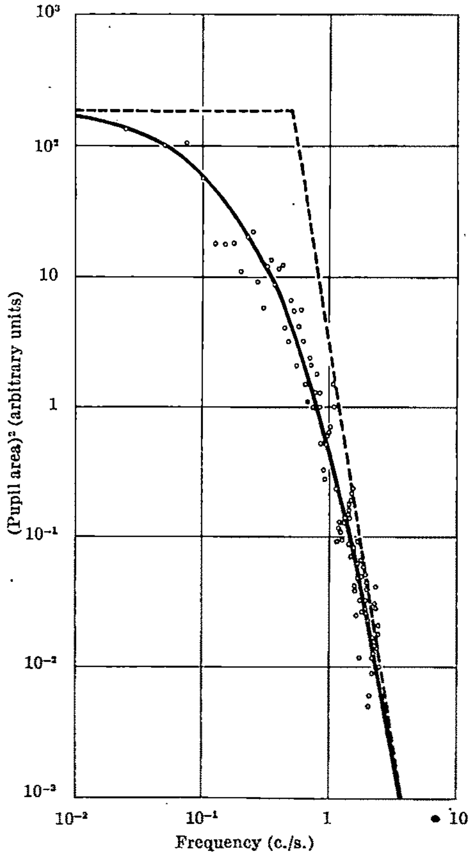

Fig. 1. Power spectrum computed from autocorrelation function of experiment No. 5. Broken lines indicate approximate asymptotes. Area squared in arbitrary units

The unrest cannot be a manifestation of instability in the pupil light reflex considered as an error-actuated servomechanism[1]. Such systems may oscillate, if the feed-back path which completes the loop carries a response delayed by time lags and sufficiently amplified to produce regenerative action[2,3]. Considerable lags exist in the pupil system, but the necessary amplification is not present as the gain is equal[4] to 0·16. The transfer function $G(s)$ is $\{0\cdot16 \exp(-0\cdot18s)\}/(1 + 0\cdot1s)^3$. Thus the pupil will not continue to respond to a stimulus that does not itself continue, and the pupil light reflex servo-loop is therefore stable. The absence of a large coherent frequency component at the frequency that such instability oscillations would be expected[1–4] is additional evidence against this possibility. Furthermore, as no regenerative instability is possible when the loop is open, pupil unrest should continue and appear unchanged under open-loop conditions. This is found to be true experimentally[5]. Thus, quite independently of the quantitative arguments above, we can discard the hypothesis that an unstable pupil loop produces the pupil unrest.

Other non-linear properties of servo-systems such as backlash or dead space also cause oscillations. However, the pupil loop does not show the change in gain with amplitude which would be found if substantial amounts of backlash or dead space were present[6]. Again, these non-linearities require closed loop operation in order to produce oscillations.

The above discussion eliminates causes of unrest associated with the closed-loop properties of the light reflex. Therefore, the unrest must originate in or be injected into the loop. Another observation suggests that this point of origin or injection must be into that portion of the loop which is common to both iris muscles. Only central nervous system elements, including the retina, comprise this portion of the loop. Fig. 2 shows the unrest of one iris to be highly correlated with the simultaneously recorded unrest of the contralateral iris. This excludes an otherwise likely source of pupil unrest—spontaneous movements of the iris muscle—of the type seen in a wide variety of smooth muscle when isolated and free from nervous influence.

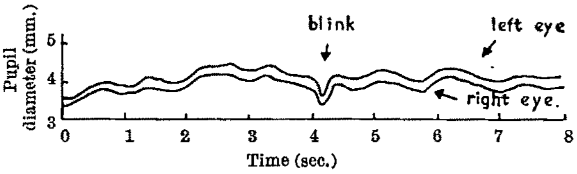

Fig. 2. Record of pupil unrest from right and left eye simultaneously, showing the high degree of correlation

The distinction between origin within and injection into the pupil reflex system can be made by comparing the frequency response of the open loop system with the power spectrum of the unrest. In Fig. 3 are plotted approximate asymptotes for (*A*) the pupil servo-system and (*B*) a lumped parameter network which would attenuate white noise to produce a power spectrum similar to Fig. 1. It is evident that the frequency distribution of the power spectrum of the pupil unrest cannot have been caused by a filtering action of either the open-loop or closed-loop pupil system on noise with uniform distribution of power with frequency. Furthermore, the filter which has shaped the power spectrum of this noise cannot be in series with the flow of information in the pupil system loop, because the measured frequency response of the pupil system does not have the 18 decibel per octave asymptote from 0·5 to 1·0 c./s.

It must be clearly understood that this band-width argument implies nothing about the actual anatomical location of the noise generator. For example, the noise may be leakage from signals external to the pupil system (cross-talk) or it may arise from part of the neurological apparatus which comprises the pupil system, as, for example, the retina. In such cases, although the noise generator and the pupil loop are anatomically united it must still be true that they are functionally and physiologically separate; that transmission of light information relevant to the operation of the pupil system cannot pass in series through the noise generator filter.

However, other experiments could localize the noise generator. For example, careful quantitative comparison under open-loop and closed-loop operating conditions could determine whether the noise is injected at the loop input or elsewhere. Because of the low loop gain and the low magnitude of the fluctuations (± 10 per cent change in area) this experiment is technically difficult and has not been satisfactorily performed. To identify the input which injects noise into the pupil system it is necessary to establish some measure of cross-correlation between the presumptive input and the pupil unrest.

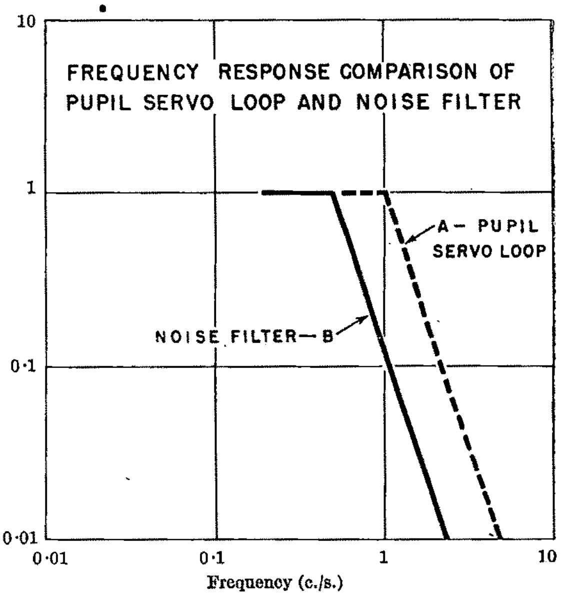

Fig. 3. Approximate asymptotes for (*A*) pupil servo-system and (*B*) lumped parameter network which would attenuate white noise to produce a power spectrum similar to Fig. 1. Both are normalized to unity gain in mid-frequency range

The role of pupil unrest. Pupil unrest might play a specific part in the visual process, or it might represent the tolerance of the pupil servomechanism to uncorrected error. It is unlikely that pupil unrest prevents the disappearance of a stabilized image[7] or produces information of value to the accommodation mechanism as use of a fixed artificial pupil does not affect the characteristics of these functions. On the other hand, since visual acuity is not appreciably influenced by a ± 15 per cent change in pupil area, it seems reasonable that pupil area need not be controlled within more precise limits. Perhaps this is an example of economy in construction in the sense that unnecessary requirements are not placed on the noise level in the pupil apparatus.

We wish to thank Prof. P. Schultheiss for helpful discussion; H. Kunz (Perkin-Elmer Corporation), Dr. G. Dahlquist and Dr. Bergstrand (Swedish Computing Board and the Yale Computing Laboratory) for carrying out the computations; Dr. Irene Lowenfield and Prof. O. Lowenstein for allowing us to conduct an experiment in their Pupillography Laboratory at Columbia University and for helpful discussion; the W. E. Durham Fund, National Institute of Neurological Diseases and Blindness, the National Science Foundation, and the W. H. Ross Fund for support for portions of this work.

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LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications.

Comparison of an Ammonia Maser with a Cæsium Atomic Frequency Standard

Several atomic frequency standards of different types are now in use for comparisons with astronomically determined time. As the adopted frequencies of these atomic standards have been derived from the smoothed universal time U.T.$_2$, which is itself variable in time[1], they disagree by several parts in 10^9. In order to obtain a uniform base for the atomic times determined by the different standards, their frequencies have to be compared directly. This has been done between cæsium resonators at the National Physical Laboratory in Teddington and the Naval Observatory in Washington using the *GBR* 19·6 kc./s. transmissions. Later the same comparison was repeated between similar cæsium resonators at the National Physical Laboratory[2].

The present communication reports on similar measurements between the cæsium resonator of the National Physical Laboratory and the ammonia maser in operation at Neuchâtel. Such a comparison is of particular interest to prove the consistency of atomic and molecular frequencies produced by completely different devices.

Two different methods of reception were used.

(1) The phase of the time signals superimposed on the *MSF* 10 or 5 Mc./s. standard frequency transmissions received in Neuchâtel was differentiated over six days centred on the days when the quartz clocks were calibrated in terms of the maser frequency standard. An accuracy of approximately ± 1 part in 10^9 is achieved.

(2) The frequency of the *MSF* 60 kc./s. standard frequency transmission is connected to the maser frequency obtained the same day. The accuracy given by this method seems better, a few parts in 10^{10}, though the reception on 60 kc./s. is often bad. The results obtained by using the corrections published by the National Physical Laboratory which have to be applied to *MSF* to obtain the frequency based on the cæsium resonator are summarized in Table 1. The correction to be applied to the adopted maser frequency (23 870 129 235 c./s.) to reduce it to the adopted cæsium resonator frequency (9 192 631 830 c./s.) is 9×10^{-9}. Within the limits of accuracy, both methods agree. It is not yet clear if the systematically lower values given by method 1 in autumn 1957 are due to relative drift of the atomic standards, statistical error or ionospheric disturbance.

Table 1. Frequency Difference Cæsium – Maser

Date	Time signals *MSF* 10 Mc./s.	Fre-quency *MSF* 60 kc./s.
	($\times 10^{-9}$)	($\times 10^{-9}$)
1957		
July 16	10	—
Aug. 19	8	—
Aug. 31	8	—
Sept. 14	8	—
Sept. 27	7	—
Sept. 30	7	—
Oct. 18	7	—
Oct. 26	7	—
Nov. 2	8	—
Nov. 4	7	—
Nov. 5	7	—
Nov. 19	7	—
Nov. 20	7	—
1957		
Nov. 21	7	—
Nov. 23	7	—
Dec. 13	7	—
Dec. 23	7	—
1958		
Jan. 4	7	—
Jan. 20	8	—
Mar. 28	8·4	9·3
April 25	9·2	9·0
May 13	10·4	9·0
June 10*	10·5	9·5
June 13*	8·0	9·3
July 3*	8·4	9·5
July 18*	10·3	8·4

* Correction *MSF* – cæsium taken as zero.

J.-P. Blaser

Observatoire de Neuchâtel.

J. Bonanomi

Laboratoire suisse de Recherches horlogères
et Institut de Physique,
Neuchâtel. Aug. 8.

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[1] Essen, L., Parry, J. V. L., Markowitz, W., and Hall, G. R., *Nature*, **181**, 1054 (1958).

[2] Essen, L., Parry, J. V. L., and Pierce, J. A., *Nature*, **180**, 526 (1957).

Comparison of Astronomical Time Measurements with Atomic Frequency Standards

Atomic frequency standards have been in regular operation in several laboratories for the past few years. It has rapidly become clear that they can be used for comparisons with astronomical time determinations.

This problem has been studied in Neuchâtel, where the atomic frequency standards (ammonia masers) have been used to define an atomic time in conjunction with a set of quartz clocks. The same clocks are related to the time determined astronomically (U.T. defining the angle of rotation of the Earth) with a photographic zenith tube and a Danjon astrolabe. The precision of these different comparisons is given roughly in Table 1.

Table 1

Type of measurement	Frequency	Ref.	Clock correction	Ref.
Atomic	10^{-10}		$3\,T + 2\sqrt{T}$ m.sec. (T in years)	*a*
Astronomical: universal time (U.T.)	$1{\cdot}6 \times 10^{-9}$	*b*	3 m.sec.	*c*
Ephemeris time (E.T.)	(5×10^{-9})	2	(30 m.sec.)	2

(*a*) Obtained by integration of the frequency of a quartz clock calibrated every two weeks in terms of atomic frequency.
(*b*) Obtained from astronomical data over a period short enough (about 1 month) to allow differentiation (ref. 1).
(*c*) Average over 1–2 weeks, the accuracy being partly limited by the uncertainty of polar motion.

It appears that atomic and astronomical clock corrections can be compared with similar accuracies whereas astronomical frequencies are much less precise. This follows from the fact that integration of atomic frequency by a quartz clock can easily be achieved without loss of relative accuracy, while astronomical data do not lend themselves to precise differentiation.

On the other hand, it seems preferable, for studying the rotation of the Earth, to use the U.T.$_1$, in which polar motion has been removed and which is a direct result of observation and therefore identical for all observatories.

If one assumes that atomic time (A.T.) is uniform, U.T.$_1$ – A.T. is a direct measure of all effects changing the rotation of the Earth. This quantity, as determined by different observatories and atomic frequency standards, should be directly comparable except for a linear term originating from the adopted atomic frequency. Fig. 1 shows such a comparison. Even small and rapid changes in the rate of rotation of the Earth can be detected, whereas these disappear in Fig. 2, where the differentiated astronomical data are plotted against atomic frequency. Besides the

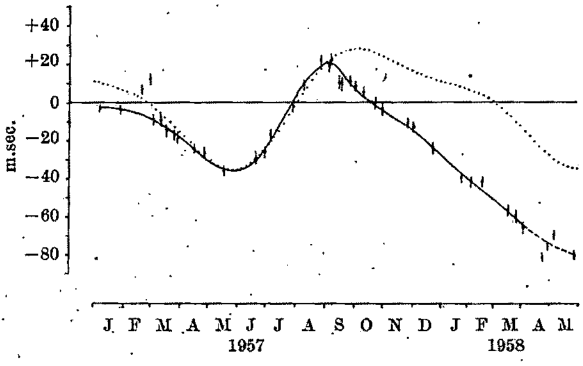

Fig. 1. Universal time (U.T.$_2$) plotted against atomic time. Points represent about 100 stars observed with the PZT. The dotted line is the predicted seasonal variation in the rotation of the Earth (T_s)

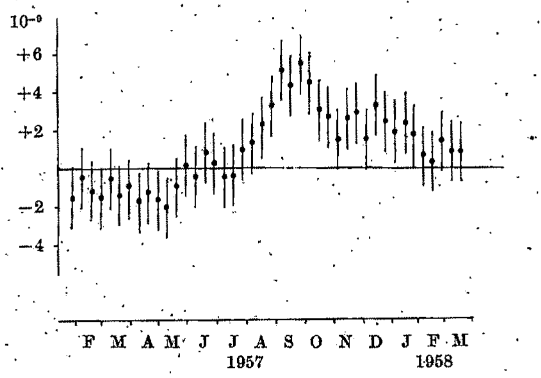

Fig. 2. Corrections to be applied to the adopted frequency of the Neuchâtel maser (23 870 129 235 *Hz*) to obtain frequency U.T.$_2$

accidental scatter of the points the gradual slowing down of the Earth of about 4×10^{-9} a year found in 1957 is in agreement with the measurements of Essen *et al.*[3]. The points in 1958 seem to indicate that this change in speed of rotation may not continue at the constant rate observed since July 1955.

Hence it would seem desirable that research centres using atomic frequency standards should also determine an integrated atomic time in order to allow a better comparison with astronomical measurements with regard to the rotation of the Earth.

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J. DE PRINS

Laboratoire suisse de Recherches horlogères
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de l'Université de Neuchâtel.
Aug. 8.

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An Irregularity in the Atmospheric Drag Effects on *Sputniks* 2 and 3 (Satellites 1957β, $1958\delta_1$ and $1958\delta_2$)

THE atmospheric drag acting on an Earth satellite shows itself most clearly by reducing the period of revolution T, and any irregularities in the rate of decrease of T are likely to be caused by irregularities in either the atmospheric density near perigee or the effective drag cross-sectional area S, of the satellite. For an orbit of small eccentricity e, the rate of change of period dT/dt is given by:

$$-\frac{dT}{dt} = \frac{3SC_D\rho_p}{m}\sqrt{\frac{\pi aH}{2e}}\{1 + 0(e)\}$$

where ρ_p is the air density at perigee, H the atmospheric scale height, a the semi-major axis of the orbit, C_D the drag coefficient (usually taken as 2) and m the mass of the satellite. Since the changes in a and e are very slow, it is ρ_p and S, and to a lesser extent H, which are likely to be responsible for irregularities in dT/dt.

Table 1. COMPARISON OF ORBITAL ELEMENTS FOR *Sputniks* 2 AND 3

Date Satellite	1957 Nov. 3.2 1957β	1958 May 15.3 $1958\delta_1$	 $1958\delta_2$	1958 Jan. 1.0 1957β	1958 Aug. 1.0 $1958\delta_1$	 $1958\delta_2$
Eccentricity, e	0·099	0·110	0·111	0·081	0·094	0·106
Perigee distance (nautical miles)	3,557	3,557	3,557	3,554	3,555	3,556
Perigee latitude	51° N.	50° N.	50° N.	33° N.	29° N.	29° N.
Inclination to equator	65·33°	65·2°	65·2°	65·30°	65·2°	65·2°

Perigee distance is from the centre of the Earth. 1 nautical mile, 6,080 ft.

In providing the prediction service for *Sputniks* 2 and 3, it has been necessary to keep day-to-day records of T, the value of which is usually obtained[1] correct to 1 part in 20,000. Fig. 1 shows the variation of T with time for each of the satellites during the first three months after launching, while Table 1 gives values of other relevant orbital elements, at launch and at one later time.

It will be seen that on all three curves in Fig. 1 a marked change in slope occurs when perigee is at

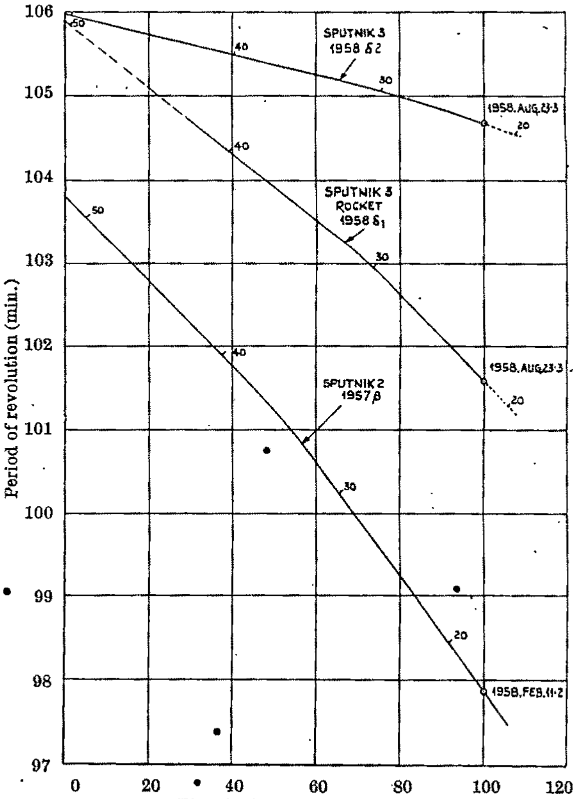

Fig. 1. Variation of period with time for *Sputniks* 2 and 3. Numbers on the curves indicate perigee latitude (deg. north).

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a latitude near 30° N., the value of $-\mathrm{d}T/\mathrm{d}t$ increasing by a factor of 1·35 ± 0·02. Also from Table 1 it appears that the orbits of the three satellites were very similar near the time of the change, and in particular that the perigee heights were almost identical.

When information was available only on *Sputnik* 2, it was not possible to say whether the abrupt change in slope was caused by a change in S or in $\rho_p\sqrt{H}$. But now the same phenomenon has occurred with three satellites of widely differing mass, shape and size, and it is scarcely credible that all three should, when their perigee latitude was near 30° N., have altered their mode of rotation so as to change their effective cross-sectional area by the same factor. The more plausible explanation is that $\rho_p\sqrt{H}$ increases quite sharply when going south near latitude 30° N.; and since H would tend to increase if ρ_p increased, it seems probable that the air density at a height of 120 nautical miles (220 km.) increases considerably somewhere between latitude 35° N. and 28° N.

If this conclusion is correct, a similar change in slope would be expected with the rocket of *Sputnik* 1 $(1957\alpha_1)$. The information available to us on this satellite is not sufficiently accurate to provide a test. Any similar changes in the United States satellites 1958α, 1958β and 1958γ would not be so readily observable because the movement of perigee is much more rapid.

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D. M. C. Walker

Royal Aircraft Establishment,
Farnborough, Hants.
Aug. 21.

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Observation of a Solar Flare at 4·3-mm. Wave-length

During a programme of solar observations at a wave-length of 4·3 mm., scans were made across the Sun on September 25, 26 and 27, 1957. The radio telescope used for these observations has a half-power beam-width of 6·7 minutes of arc. The antenna reflector is an aluminium paraboloid, 10 feet in diameter with a focal length of 35·8 inches. The receiver is mounted on the back of the antenna and is a Dicke-type radiometer consisting of a superheterodyne receiver preceded by a motor-driven attenuator wheel. This radio telescope has been described in a previous publication[1]. The observations were made by pointing the antenna ahead of the Sun and locking it in position. The radiometer output was then recorded continuously as the Earth's rotation carried the Sun's image through the antenna beam. The scans were made across a large plage region located in the eastern part of the solar disk. The scans for each of the three days are shown in Fig. 1. The observed enhanced radiation from the plage region is clearly evident on all three scans. The scan on September 26 was made at the time of the maximum of an importance 3 solar flare occurring in the plage region. The enhancement recorded on September 26 is about twice the enhancement for the two scans made on the day before and the day after the flare. This indicates that the enhanced radiation is from the flare.

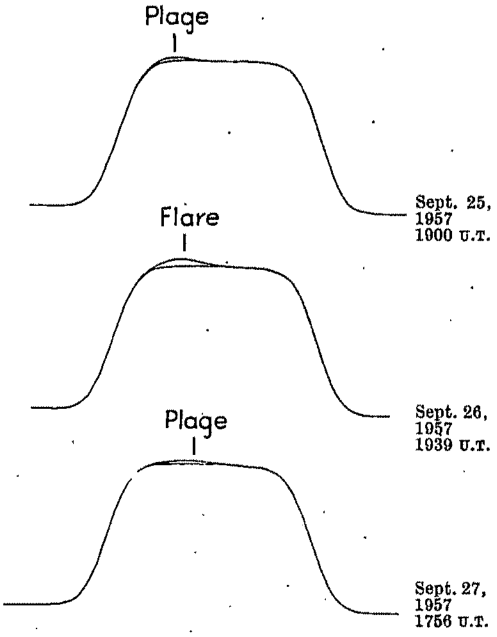

Fig. 1. 4·3-mm. solar scans across plage region and flare of importance 3. Upper curves, observed scans; lower, quiet sun scans for comparison

McCullough at the Naval Research Laboratory recorded the 9·4-cm. solar radiation on September 26, and Fig. 2 is his record of the burst observed coincident with the importance 3 flare. The increase in flux at 9·4 cm. was about 40 per cent at 1938. The observed increase at 4·3 mm. corresponds to a flux increase of 0·36 per cent with respect to the entire disk. Thus the per cent increase of flux at 4·3 mm. was about 1/100 of that at 9·4 cm.

The areas of the plage region before and after the flare and the area of the flare were determined from H-alpha photographs made with a flare patrol camera[2]. These areas were used to compute the average brightness of the plage and flare that would produce the observed enhanced radiation at 4·3-mm. wave-length. The average brightness temperature for the plage came out to be 8,100° K., which is to be compared with the 7,000° K. brightness temperature[1] of the quiet solar disk at 4·3 mm. The brightness temperature for the flare was 14,400° K. Neither the brightness temperature for the flare nor the plage is exceedingly high, and therefore it is fairly easy to explain the observed enhanced radiation as just thermal radiation from the flare area and from the plage area.

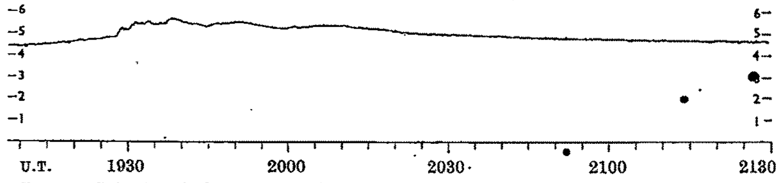

Fig. 2. Solar burst, λ = 9·4 cm., Sept. 26, 1957. Horizontal axis represents sky-level

R. J. Coates

Radio Astronomy Branch,
U.S. Naval Research Laboratory,
Washington, D.C. Aug. 5.

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Tensile Strength of Indium

Eppelsheimer and Reitsma[1] have recently pointed out that a tensile strength of 7·99 tons/in.^{2} hitherto ascribed to indium containing 0·29 per cent impurities was really the value for gold containing 0·29 per cent indium. For this reason they redetermined the tensile properties of 99·97+ per cent indium, finding tensile strength 388 lb./in.^{2} and 70 per cent elongation.

About six years ago, Jaffee and Weiss[2] reported the tensile strength of pure indium (metal as annealed one week at 230–266° F.) as 380 lb./in.^{2}, elongation 22 per cent on 1 in. They make acknowledgment to Consolidated Mining and Smelting Co. of Canada, Ltd., for permission to publish, so presumably the indium used was derived from the latter, which also quotes these results in its pamphlet on indium.

Note added in proof. Since this was written an earlier determination has come to light. In 1943, A. H. Stang and B. L. Wilson[3] (Bureau of Standards) found a tensile strength of 430 lb./in.^{2} for 99·9 per cent metal from the Indium Corporation of America.

B. FULLMAN

British Non-Ferrous Metals Research Association,
Euston Street, London, N.W.1. Aug. 7.

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Photoconductivity and Crystal Size in Evaporated Layers of Cadmium Sulphide

THE photoconductive properties of evaporated layers of cadmium sulphide have been the subject of relatively few studies as compared with the number of those applied to single crystals. Aitchinson[1] showed some years ago that layers obtained by evaporation in a very good vacuum (better than 10^{-6} mm.) were photoconductive. His results were recently repeated by Nelson[2], who pointed out the influence of the chemical purity of the starting material. In general, evaporated layers acquire their optimum photoconductive properties only after an activation treatment which may be provided by heating in air[3] or heating in an inert atmosphere after covering by a thin evaporated layer of metal as was indicated by Veith[4].

During the investigation of this last process we observed a peculiar phenomenon of crystal growth in evaporated cadmium sulphide layers. The cadmium sulphide was deposited on glass plates the temperature of which could be controlled during the process. It was found that if the temperature was maintained at about 200° C. the layers were of microcrystalline nature and had a very well oriented structure: an X-ray diagram of such a layer, taken with a goniometer, shows only the 0002 lines and their higher orders. The diffraction lines are relatively sharp, but the Cu$K\alpha_1$, α_2 doublet is not resolved. That means that the individual crystals must have a size of the order of 1000 A. If such a layer is covered with a film of evaporated silver of thickness approximately equal to 100 A. and then heated to 500–600° C. in an inert atmosphere it frequently but not always happens that the layer recrystallizes and shows, after heat treatment, only the $1\bar{1}03$ or the $1\bar{1}05$ X-ray diffraction line. Furthermore, the X-ray diffraction lines are then very sharp and the Cu$K\alpha_1\alpha_2$ doublet is well resolved even at low angles.

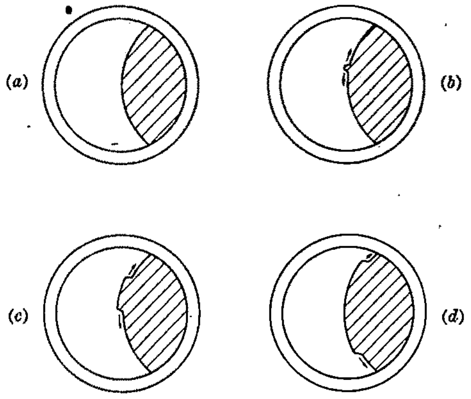

Fig. 1. Growth mechanism. The etched area represents a recrystallized region in which the direction of growth is from *a* to *d*

Cadmium sulphide having a hexagonal lattice, it is possible to observe the growth of the crystals in a glass furnace between two crossed polaroids. Under our experimental conditions the growth front velocity varied between 0·1 and 0·5 mm. per sec. The growth front does not progress as a whole; recrystallization is more or less a local phenomenon and it sometimes was observed that the recrystallization progressed in small bands perpendicularly to the motion of the growth front (Fig. 1). It is certain that the silver plays an active part in the process: samples partly covered by bands or dots of evaporated silver never showed any sign of recrystallization in the uncovered parts. Recrystallization was obtained with other substances, the first being copper the activity of which is similar to that of silver. The others are lead, indium, aluminium, bismuth, zinc and even zinc sulphide. The size of the crystals obtained with these last substances is relatively small, whereas those obtained with silver could be as large as the sample itself, that is, 12 mm. in diameter.

The photoconductivity of these layers seems to be very sensitive to traces of impurities, and the connexion between recrystallization and photoconductivity can only be expressed in a statistical form: seventy samples which had been activated in the same way were examined. Some of them were recrystallized, others not. The ratio of the electrical conductivity under an illumination of 100 lux to the dark conductivity was used as a quality factor. The

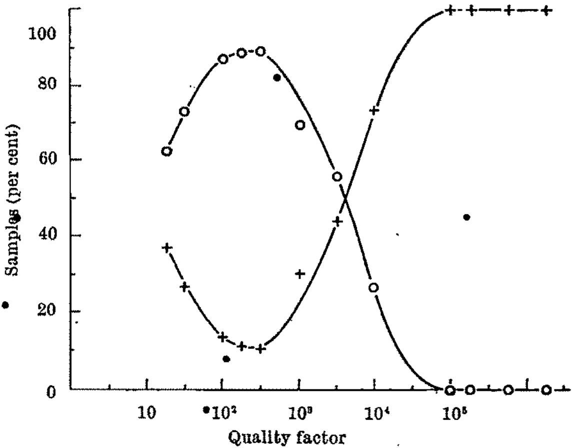

Fig. 2. Percentage of samples as a function of their quality factor. +—+, Recrystallized samples; O—O, unrecrystallized samples

experimental range of quality factors was from 1 to 10^6. This scale is divided into intervals, and in each interval one plots separately the per cent of recrystallized and unrecrystallized samples (Fig. 2). Good samples are found only among the recrystallized samples. Furthermore, a careful examination of the specimens indicates that the quality factor and the absolute intensity of the photocurrent are the highest in the samples with the largest and most perfect crystals.

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Identity of Ions in Some Flames

Some results reported in a previous communication in *Nature*[1] have shown the possibility of mass spectrometric identification of the ions present in some flames. More results have now been obtained which suggest a comparison between different kinds of flames burning at a pressure of about 10 mm. mercury instead of the pressure of 40 mm. chosen in our earlier experiments.

The bare determination of the mass number of the observed peaks is not sufficient to identify unambiguously the corresponding ions; however, by burning partially deuterated fuel, the hydrogen content of the ions can be carefully checked.

The ions described here are given in sequence of decreasing abundance. The figures under the heading "Hydrogen content" are the number of hydrogen atoms contained in each ion; these figures are, of course, one unit less than the number of peaks into which the original single peak is split when partially deuterated fuel is burned. Furthermore, it was shown that the relative intensity of the split peaks corresponds fairly well to what can be estimated from the percentage of deuterium in the fuel molecule. All results reported here (Table 1) concern flames which are being propagated in undiluted mixtures rich in fuel (except when otherwise stated); the flames were kept as near as possible to the hole through which the ions are extracted.

From these results, the following conclusions may be derived: (1) There seems to be a tendency for H^+ to be attached to polar molecules such as H_2O, NH_3 and HCN. (2) NH_4^+ can be formed as soon as the flame is propagated in a mixture where nitrogen is a part of the fuel or of the oxidizer molecule. (3) Once too great an amount of NO is present in the burned gases, most of the ions are NO^+. This is probably due to the lower ionization energy of NO (charge transfer in the flame front).

This last point is confirmed by the following observation: peak intensities decrease when the ions are sampled at a larger distance ahead of the flame: the rate of this decrease is not the same for all ions and, in some cases, one observes first for NO^+ a slight increase after which, because of recombination, the normal decrease is observed.

Table 1

Mixture	Mass units	Hydrogen content	Identity of ion	Remarks
C_2H_2/O_2	19	3	H_3O^+	
	37	5	$H_5O_2^+$	Only in flames diluted with nitrogen and at a rather higher pressure (at least 25 mm. mercury)
	39	3	$C_3H_3^+$	Only in rich flames
	29	1	COH^+	
	30	0	NO^+	Does not appear when no nitrogen is added to the flame

The masses 19, 37 and 39 correspond to about 95 per cent of the total ion concentration.

Very weak peaks are noticed at masses 13, 14, 17, 18, 24, 26, 28 and 43 (less than 0·1 per cent).

Mixture	Mass units	Hydrogen content	Identity of ion	Remarks
C_2H_2/N_2O	30	0	NO^+	At least 90 per cent
	18	4	NH_4^+	
	19	3	H_3O^+	
	28	2	H_2CN^+	
	39	3	$C_3H_3^+$	Only in rich mixtures
	29	1	COH^+	
	43	?	?	Too weak to check hydrogen content

Very weak peaks at masses 26, 31, 41, 44 (less than 0·1 per cent).

Mixture	Mass units	Hydrogen content	Identity of ion	Remarks
CH_4/O_2	19	3	H_3O^+	
	29	1	COH^+	Only about 1 per cent
C_2H_2/O_2 with about 1 per cent NH_3				More or less the same mass spectrum as in the case of C_2H_2/N_2O flames; however, the NO^+ peak is relatively weaker.
C_2H_2/O_2 with about 2 per cent HCN				The ratio H_2CN^+/NO^+ is about the same in both cases, NH_4^+ is less important with the addition of HCN than of NH_3.

We have not systematically extended our investigations beyond 45 mass units. Some higher masses are reported by P. F. Knewstubb and T. M. Sugden[2]; in our low-pressure flames the corresponding peaks are absent or much weaker than those observed by these authors on flames burning at atmospheric pressure.

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Gas Chromatograph as a Methanometer in the Coal Industry

Gas-solid chromatography has now found acceptance for the determination of hydrogen in mine atmospheres. The instruments developed for this purpose also give a complete separation of methane. An investigation was therefore undertaken to determine the possibility of using the existing instruments for routine or emergency estimation of methane in cases where the higher accuracy of the Haldane apparatus was not necessary, or when the use of volumetric combustion methods was not practicable. For routine use the gas chromatograph has the advantage of speed and specificity, and moreover it can be operated by semi-skilled personnel.

The apparatus used in these experiments was the gas chromatograph for the determination of hydrogen in mine airs, developed by the National Coal Board (North-Western Division) for use in its Area

Laboratories. This is similar to the instrument described by me in an earlier communication[1], using active carbon column packings and nitrogen as the carrier gas, and differing only in that while the columns and detector of the earlier instrument were maintained at 30° ± 0·05° C., in later instruments no thermostat was used, columns and katharometer being immersed in an oil-bath containing 6·5 l. of transformer oil. Even when room temperature is varying quite rapidly, the high thermal capacity of the oil-bath serves to maintain the temperature of the columns and katharometer reasonably constant during the short time required for the separation. After calibration with a standard methane/nitrogen mixture, a number of analyses may be carried out before re-standardization becomes necessary.

The experiments were carried out using a number of methane/nitrogen mixtures, with methane contents in the range 0·65–94·8 per cent. The composition of these mixtures was established from repeated volumetric combustion analyses using a Haldane apparatus, after dilution of the samples with the necessary volume of air. 10 ml. samples were taken for analysis by gas chromatography.

Plotting peak height against methane concentration, the curve shown in Fig. 1 was obtained. In the range of methane concentration 0–5 per cent the curve is nearly linear; from 5–45 per cent there is considerable curvature, while above 45 per cent the curve again becomes almost linear. The occurrence of two linear regions seems to follow from the variation of peak width with component concentration. Samples containing up to 5 per cent methane give peaks of practically constant width. Above 5 per cent, the methane peak 'tails', the peak width increasing rapidly with concentration up to about 45 per cent methane; further increase of methane concentration up to 95 per cent gives only a very slight increase in peak width, and the relationship between peak height and concentration is again linear, though the extrapolation of this line does not pass through the origin. The change in the shape of the methane peak with concentration is shown in Fig. 2. No theoretical explanation can be offered for the constant width of the peak for concentrations above 45 per cent. Further 'randomized block' experiments covering the concentration ranges 0–5 and 45–100 per cent confirmed the linearity in these regions, and indicated that the precision of a single determination in the 0–5 per cent range was ±0·08 per cent, and ±1·2 per cent in the 45–100 per cent range. Fortuitously, the methane/air mixtures, which are of the greatest importance in the coal industry, namely, mine airs and methane drainage gases, in general have methane contents lying within the linear regions. If peak areas rather than peak heights are measured, the response/concentration curve becomes almost linear over the whole range, but the precision is slightly less, because of additional error introduced in the measurement of the areas. Clearly, for the purpose of routine analysis, it is advantageous if measurement of peak height can be substituted for measurement of peak areas. Whichever measurement is taken, the method has considerable scope for the analysis of mine airs, including fire and methane drainage gases, since it provides a rapid and specific determination of both hydrogen and methane on one sample.

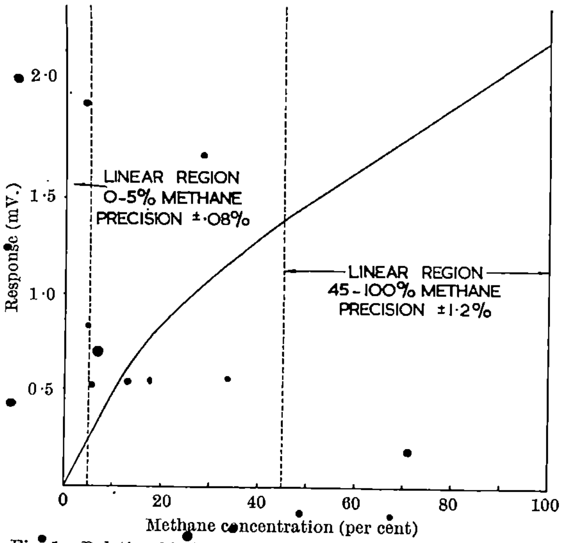

Fig. 1. Relationship between peak height and methane concentration

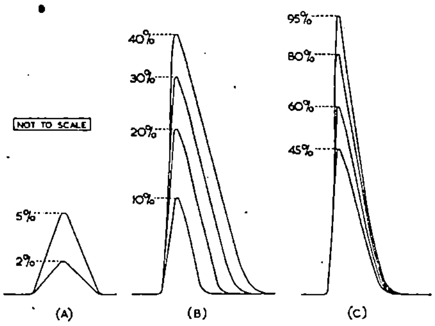

Fig. 2. Changes in peak shape with methane concentration. (*A*) shows constant peak width over range 0–5 per cent methane, (*B*) shows increase in peak width from 40 per cent, (*C*) nearly constant peak width above 45 per cent

The gas chromatograph appears to be a valuable analytical tool for the determination of methane in methane drainage gases on account of its specificity, since other hydrocarbon gases are frequently present; this makes a methane determination by the volumetric combustion method lengthy and of doubtful accuracy. In this connexion it may be noted that ethane, in amounts of 1–6 per cent, appears to be a normal constituent of methane drainage gases from collieries in Lancashire and North Wales, a notable exception being the gas from Point of Ayr Colliery, North Wales, which is free from hydrocarbons other than methane. As ethane is not eluted as a recognizable peak from carbon columns at room temperature, separation of ethane and hydrocarbons up to C_5 has been carried out on 3-m. columns of active alumina modified with paraffin wax, at temperatures between 25° C. and 60° C., using hydrogen as the carrier gas. A full account of this work will be published at a later date.

Acknowledgment is made to D. H. Ward for the statistical analysis of the experimental results.

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Separation of Some Tobacco Alkaloids by Gas Chromatography

Gas chromatography has been employed in separating numerous types of compounds, but has not yet been applied to the alkaloids, a field where it might find particular utility. We wish to report preliminary results clearly indicating the usefulness of gas chromatography in the study of the tobacco alkaloids. Other families of alkaloids having slight volatility and good thermal stability may also prove to be separable under similar conditions.

For the stationary liquid phase we found certain polyglycols (Table 1) preferable to the less-polar materials, such as 'Apiezon' grease and the silicones, commonly used in high temperature work. The stability and non-volatility of the polyglycols are sufficient to permit continuous use of columns for several days without appreciable changes in their retention ability. The alkaloids were eluted in sharp, symmetrical peaks with columns containing the polyglycols.

Table 1

	Columns and conditions		
Liquid phase	Polyethylene glycol (*a*)	Polypropylene glycol (*b*)	Polybutylene glycol (*c*)
Temperature	190° C.	190° C.	180° C.
Helium flow (ml./min.)	48	45	50
	Retention time (min.)		
3-Pyridyl methyl ketone	4·3	4·3	3·1
3-Pyridyl ethyl ketone	5·3	6·1	5·0
3-Pyridyl *n*-propyl ketone	6·6	8·1	7·0
Nicotine	5·2	8·6	8·2
Nor-nicotine	12·3	16·1	14·3
Myosmine	13·4	16·4	14·7
Anabasine	13·8	19·4	18·1
Metanicotine	16·5	23·5	20·9
Nicotyrine	19·4	21·0	18·3
Cotinine	85	79	63

(*a*) Molecular weight, 20,000 (Dow Chemical Co.). (*b*) Molecular weight, 1,025 (Union Carbide Chemical Co.). (*c*) Molecular weight, 1,500 (Dow Chemical Co.).

The polyglycol columns exhibited good selectivity for the alkaloids, making possible the separation of most of the members of complex mixtures. This is seen from the retention-time data in Table 1. The elution sequence is identical on the polypropylene and polybutylene columns, although some relative differences in retention times are observable. A slightly different sequence was noted for the polyethylene glycol column. These effects are valuable in that a separation of two alkaloids difficult on one column may be feasible on another.

That the structure of the alkaloids had not been altered by the rather severe conditions of the gas chromatographic technique was established by obtaining ultra-violet absorption spectra for samples condensed from the gas stream as the elution peak for an alkaloid, run individually, was being recorded. In every case, the collected and starting compounds were identical. Paper chromatographic studies, using solvent systems *S*1 and *L*5 of Kuffner *et al.*[1], were also performed in some cases and verified this conclusion.

The Perkin–Elmer Vapor Fractometer, Model 154–*B*, modified to include a thermostat for the column chamber and a heater on the vent line from this chamber, was used in this study. Samples were 20λ aliquots of benzene solutions containing 5–10 mgm. per ml. of the alkaloids. Helium was used as carrier gas. The solid support was alkali-washed firebrick; liquid phases were placed thereon in the weight ratio of 1 to 4. Columns were U-tubes of 6 mm. outside diameter glass tubing, 1 m. long. The helium flow was determined at the vent with a soap-bubble meter at room temperature.

The alkaloid fraction of cigarette smoke is being investigated with the techniques described here. Results will be published in a subsequent paper.

We are indebted to the American Tobacco Company and to Drs. R. F. Dawson and R. N. Jeffrey for generous gifts of alkaloids. This work was supported by a grant from the Damon Runyon Memorial Fund.

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Complex Phospholipids

Recent work has revealed the existence of hitherto unsuspected phospholipids in addition to the three major components, lecithin, phosphatidyl ethanolamine and phosphatidyl serine, and two minor components, sphingomyelin and phospho-inositide. Lea, Rhodes and Stoll[1], by chromatography on silicic acid, obtained lysolecithin and lysocephalin from egg yolk phospholipids, and Marinetti, Erbland and Kochen[2] have shown by paper chromatography that unidentified phospholipids were present in a number of tissues. This work is supported by the results obtained by Dawson[3] and Benson and Maruo[4]. Collins and Wheeldon[5], working with the N-2 : 4-dinitrophenylated and methylated derivatives of the phospholipids from rat and sheep brain and rat liver, have shown the presence of a fraction of the ethanolamine- and serine-containing phospholipids which corresponds neither to phosphatidyl ethanolamine nor to phosphatidyl serine. The present work is concerned with the presence of additional new and as yet unidentified compounds in this fraction.

Rat liver lipids, after N-2 : 4-dinitrophenylation and methylation as described by Collins and Wheeldon[5], were separated into polar and non-polar fractions by counter-current distribution in 85 per cent (v/v) aqueous ethanol-light petroleum. The non-polar fraction was further fractionated by chromatography on 'Hyflo-Supercel' (1 mgm. lipid to 2 gm. of adsorbent) and four materials containing phosphorus separated by elution with the solvent sequence, light petroleum, light petroleum-benzene mixtures, benzene, benzene–chloroform mixtures and chloroform. The characteristics of these four fractions are shown in Table 1.

Chromatography of the polar fraction led to its decomposition, but counter-current distribution enabled the isolation of three dinitrophenyl-containing compounds and certain of their properties have been determined (Table 2). One of these compounds has been isolated in sufficient quantity for a full analysis and appeared to be homogenous as shown by the distribution curve. Sheep brain lipids were found to be the best source for its isolation.

Determination of the molecular weight by an isopiestic method[6] and by the depression of the freezing point in cyclohexane indicated values of

Table 1. Properties of the Phospholipids in the Non-Polar Fraction of Rat Liver Lipids

	X	*Y*	*Z*	Phosphatidyl ethanolamine and serine
Partition coefficient in:				
Methanol-petroleum (100–120° C.)	3·6	1·5	0·9	0·6
85 per cent (v/v) aqueous ethanol-light petroleum	12·0	4·7	—	1·6
Absorption maximum	none	none	410 mμ	328 mμ
Phosphate as percentage of the total lipid phosphate	0·78	0·33	1·15	9·40

2030 and 2200 respectively. Elementary analysis assuming two atoms of phosphorus per molecule indicated the empirical formula $C_{105\pm1}H_{183\pm2}N_6O_{29}P_2$. The substance contained no free amino-groups, no aldehydogenic groups and no sulphur. The absorption maximum, due to the dinitrophenyl group, was at 333–335 mμ (E = 17,200).

The material was hydrolysed by refluxing with ethanolic 2 *N* hydrochloric acid for 3 hr. and the hydrolysate divided into three fractions: (1) light petroleum-soluble; (2) insoluble in light petroleum but soluble in diethyl ether; (3) insoluble in diethyl ether but soluble in water.

Fraction (1) was refluxed with 2 *N* potassium hydroxide (1 : 1 water-ethanol by volume) for 3 hr. and the unsaponifiable material separated by extraction into diethyl ether; analysis of this material, which constituted 23 per cent of the complex phospholipid and on which a Liebermann–Burchard test was negative, showed the presence of 1·04 hydroxyl-group/mole. The fatty acids were recovered by acidification of the soaps and extracted into diethyl ether, and yielded 1·92 moles/mole.

Fraction (2) contained dinitrophenyl-ethanolamine (0·95 mole/mole) and dinitrophenyl-serine (0·05 mole/mole) and no other material containing dinitrophenyl as shown by paper chromatography using the solvent systems described by Collins and Wheeldon[7].

Fraction (3) contained 1·95 mole phosphorus/mole and less than 5 per cent was in the form of inorganic phosphate. On paper chromatography only one phosphate spot could be detected and this was identical in behaviour with glycerol-1-phosphate in five solvent systems. It was thus concluded that 2 moles/mole of glycerol-1-phosphate were present. Paper chromatography also showed the presence of choline (0·96 mole/mole) and a reducing sugar (0·96 mole/mole) which was either glucose or galactose.

Fraction (3) contained 0·99 mole/mole and fractions (1) and (2) together contained 1·09 mole/mole of unidentified compounds containing nitrogen. The presence of these materials in sheep brain complex phospholipid indicates that similar complex phospholipids may account for some of the unidentified compounds containing nitrogen that have been described in phospholipids in other tissues[8].

Table 2. Properties of the Amino-Phospholipids in the Polar Fraction of Rat Liver and Sheep Brain Lipids

Fraction	1	2	3
Partition coefficient in carbon tetrachloride/methanol/water (62 : 35 : 3·15 v/v/v) (ref. 9)	1·0	2·5	8
Carbon tetrachloride/chloroform/methylene chloride/methanol/water (25 : 15 : 10 : 40 : 10 by vol.) (ref. 11)	0·2	0·5	4
Amino-nitrogen as percentage of the total amino-nitrogen in rat liver lipids	5	35	11
Amino-nitrogen as percentage of the total amino-nitrogen in sheep brain lipids	25	13	16

This complex phospholipid from sheep brain may consist of one molecule of lysolecithin and one molecule of lysophosphatidyl ethanolamine joined together by a compound containing no phosphorus made up of the two unidentified residues containing nitrogen, the sugar and the fatty alcohol. However, the precise nature of this material cannot be determined without further chemical studies.

A full description of this work will be published elsewhere.

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Thyroxine-binding Protein in the Serum of Rabbit Fœtuses

Human serum contains a thyroxine-binding protein which moves to a position between the α_1 and α_2 globulins on paper electrophoresis in a barbiturate buffer[1]. We have investigated the thyroxine-binding power of maternal and fœtal serum taken from pregnant rabbits at different stages of pregnancy. L-Thyroxine, labelled with iodine-131 and having a specific activity of 5 μc./μgm., was added to samples of the serum to give a concentration of about 0·05 μc./ml. of serum. Half to one hour later, 0·02 ml. of the serum was put on to a strip of Whatman No. 3 *MM* filter paper and electrophoresis carried out as described elsewhere[2], using a barbiturate buffer at *p*H 8·6 and ionic strength 0·1. After the current had been passed for 18 hr. the papers were dried and the position of the radioactivity determined by means of a continuously recording scanner. The bands of protein on the paper were then stained with lissamine green.

At all the stages of pregnancy examined, the radioactivity in the maternal serum was confined mainly to a single peak between the albumen and the α_1 globulin (Fig. 1c). In some cases there were also small peaks near the region of the β-globulin and at the position of the albumen. In the fœtal sera the protein composition, as revealed by the intensity of staining, varied according to the age of the fœtus. At the 19th day of pregnancy the albumen band was much weaker than that in the mother, the α_1 was absent and the α_2 was stronger than the β-band. As the age of the fœtus increased, the relative intensities of the different bands came to resemble more closely those in the mother. Before the 30th day the fœtal serum showed no radioactivity at the position corresponding to maternal thyroxine-binding protein, but at all stages from the 19th to the 28th days there was a single peak between the

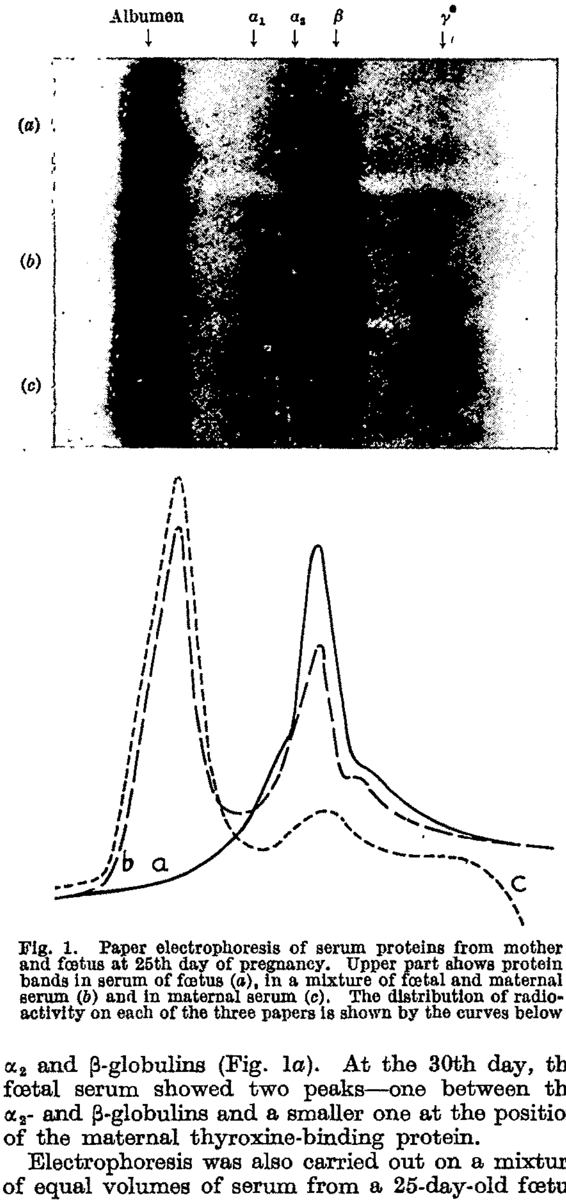

Fig. 1. Paper electrophoresis of serum proteins from mother and fœtus at 25th day of pregnancy. Upper part shows protein bands in serum of fœtus (*a*), in a mixture of fœtal and maternal serum (*b*) and in maternal serum (*c*). The distribution of radioactivity on each of the three papers is shown by the curves below

α_2 and β-globulins (Fig. 1*a*). At the 30th day, the fœtal serum showed two peaks—one between the α_2- and β-globulins and a smaller one at the position of the maternal thyroxine-binding protein.

Electrophoresis was also carried out on a mixture of equal volumes of serum from a 25-day-old fœtus and the serum from its mother, after labelled thyroxine had been added to the mixture. Two separate peaks of radioactivity were observed—one between the α_2- and β-globulins and the other at the position of the maternal thyroxine-binding protein (Fig. 1*b*).

The relative amount of thyroxine bound by the fœtal and maternal binding proteins at different stages of pregnancy was studied *in vitro* by comparing the heights of the two peaks of radioactivity in mixtures of fœtal and maternal serum. At increasingly early stages of pregnancy there was a decrease in the ratio of the height of the fœtal to that of the maternal peak of radioactivity. At the 19th day radioactivity at the position of the fœtal binding protein was scarcely discernible in a mixture of the fœtal and maternal sera; by the 28th day the height of the peak between the α_2- and β-globulins was almost half as high as that behind the albumen.

We conclude that the specific thyroxine-binding protein of adult serum is not present in the fœtus until about the 30th day, but that the fœtal serum contains one or more binding proteins with an electrophoretic mobility intermediate between that of the α_2- and β-globulins. Binding power is present in the serum of 19-day-old fœtuses, but at this stage of pregnancy it is much weaker than that in the maternal serum. By the end of pregnancy, the binding power of the fœtal serum is nearly half as great as that of the mother's serum.

It has been shown that when thyroxine is injected into the maternal circulation in early pregnancy, very little appears in the fœtal circulation[3,4]. If, however, the injection is made at later stages of pregnancy, increasing amounts of thyroxine reach the fœtal circulation[5]. This apparent increase in the permeability of the placenta to thyroxine may be explained by the increasing binding power of the fœtal serum. Thus, if the placenta were at all times permeable to unbound thyroxine, but impermeable to bound thyroxine, thyroxine injected into the mother should distribute itself between the maternal and fœtal circulations in the ratio of their respective binding powers.

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An Indirect Action of Angiotensin I on Smooth Muscle

THE stimulatory action of angiotensin I (angiotonin, hypertensin) on isolated ileal segments was investigated to determine whether this action is entirely a direct one on the muscle fibre. Some evidence for an indirect action was obtained mainly by the use of botulinum toxin, which causes functional cholinergic denervation of the muscle.

The tissue was left in contact for 30 min. with 10 mgm. of toxin type *A* (equivalent to $2\cdot5 \times 10^7$ mouse *LD*50) or for 60 min. with 100 mgm. of toxin type *D* (equivalent to 3×10^6 mouse *LD*50) in 2–3 ml. bathing fluid at 37° C. The contractions of the longitudinal muscle of rabbit ileal segments in a 10 ml. bath to doses of 0·15–0·2 μgm. acetylcholine, 5–10 μgm. nicotine and 0·5–3·0 Indianapolis units of angiotensin I (4 min. contact), which were equiactive before toxin treatment, were compared after toxin. In four out of four experiments the responses to acetylcholine remained unaltered, those to nicotine were abolished and those to angiotensin were markedly reduced or abolished. Moreover, in four out of four preparations without toxin treatment, the addition of the true cholinesterase inhibitor *BW* 284*C*51 (2×10^{-7} gm./ml.) potentiated the responses to both nicotine and angiotensin and, in three out of three experiments, hexamethonium (3×10^{-4}) reduced the responses to angiotensin by an average of 50 per cent although those to acetylcholine control doses were not reduced.

On the only occasion on which it was tested, type *D* toxin did not alter the slow contraction of guinea pig ileum to angiotensin; however, it completely abolished the quick contraction which occurred on washing out angiotensin from the bath. No similar quick contractions on washing out angiotensin were observed in rabbit ileal preparations.

Thus it appears that at least part of the action of angiotensin I on some isolated ileal preparations is indirect, being mediated through cholinergic neurones.

We wish to thank Dr. O. M. Helmer of Indianapolis for a supply of angiotensin I and Dr. J. Keppie of Porton for the botulinum toxin.

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Sorbitol Dehydrogenase in Spermatozoa

It has been shown previously that the addition of sorbitol to actively respiring suspensions of washed, motile ram spermatozoa causes an increase in the consumption of oxygen, accompanied by an oxidative conversion of sorbitol to fructose and followed by the ærobic glycolytic breakdown of fructose to lactic acid[1]. More recently, it was established that sorbitol, like fructose, actually occurs as a normal constituent in the seminal plasma of ram, bull, man and certain other species[2]. These findings make it highly probable that lactic acid, which accumulates in normal semen on aerobic incubation *in vitro*, is in fact in part the product of direct glycolysis from preformed seminal fructose, but partly also originates from the metabolism of sorbitol *via* fructose.

In the course of experiments designed to elucidate the mechanism of sorbitol oxidation it was noted that not only are ram spermatozoa able to oxidize sorbitol, either in the presence of molecular oxygen or artificial electron acceptors, such as triphenyltetrazonium chloride, but that they are also capable of reducing fructose to sorbitol, both aerobically and anaerobically. The reduction of fructose to sorbitol probably explains our observation that the content of sorbitol in freshly ejaculated ram semen is apt to increase on standing. When instead of fructose, glucose is added to a washed sperm suspension, a reduction to sorbitol also occurs, but at a much lower rate.

In an attempt to extract the enzyme responsible for the oxido-reduction of sorbitol to fructose, various methods were used such as grinding the sperm with glass powder, freezing and thawing, shaking in a Mickle disintegrator, preparation of acetone-powder and treatment with hypotonic solutions and detergents. None of these procedures, however, yielded a positive result. A partial disintegration of spermatozoa, accompanied by the appearance of small quantities of a soluble enzyme, was achieved by the use of the Mullard magnetostriction transducer Type *E*7590*B* at 500 watts and 25 kc./s. for 10 min. Finally, however, a method has been elaborated which makes it possible to prepare the enzyme in a completely soluble form. This was accomplished by applying a treatment similar to that developed by McIlwain for the preparation of cell-free extracts from certain bacteria[3]. The well-washed and sharply centrifuged ram spermatozoa were ground with lavigated aluminium oxide (Hopkin and Williams Ltd.) and this was followed by extraction with cold 0·025 *M* phosphate buffer, *p*H 7·3. On centrifugation of the extracts, first in a refrigerated M.S.E. centrifuge and afterwards in a 'Spinco' preparative centrifuge (for 45 min. at 40,000 r.p.m.), clear solutions were obtained, approximately 30 ml. for each 10 ml. of ram semen used. The solutions thus obtained showed on spectrophotometric examination a ratio of about 0·5 between light extinction at 280 (E_{280}) and 260 mμ (E_{260}). Treatment with protamine sulphate produced a voluminous precipitate which, however, could be removed without affecting the content of the enzyme. The filtrates, exhibiting a markedly higher ratio between E_{380} and E_{260}, were used for further fractionation.

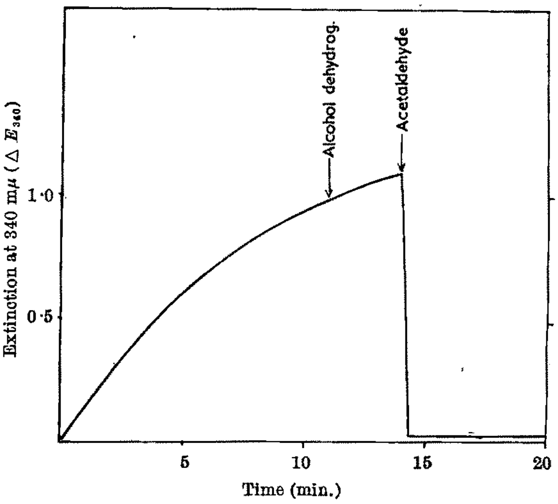

Fig. 1. Oxidation of sorbitol by the sorbitol dehydrogenase obtained from ram spermatozoa. The oxidation of sorbitol was followed by measuring spectrophotometrically the extinction at 340 mμ, due to reduced diphosphopyridine nucleotide, in a 1-cm. cuvette. The reaction mixture (3 ml.) contained 1 μmole diphosphopyridine nucleotide, 100 μmoles of sorbitol, 60 μgm. enzyme, and 0·033 *M* tris buffer, *p*H 8·6. The control mixture, from which sorbitol was omitted, did not reduce diphosphopyridine nucleotide. The re-oxidation of reduced diphosphopyridine nucleotide was carried out by the addition of 50 μgm. of crystalline alcohol dehydrogenase prepared from yeast and 80 μmoles of acetaldehyde

The soluble enzyme prepared from spermatozoa required diphosphopyridine nucleotide (DPN) for the following reversible reaction :

$$\text{sorbitol} + \text{DPN}^+ \rightleftharpoons \text{fructose} + \text{DPNH} + \text{H}^+$$

Triphosphopyridine nucleotide was unable to replace diphosphopyridine nucleotide in the above reaction. The rate at which diphosphopyridine nucleotide was reduced is shown in Fig. 1, whence it can also be seen that reduced diphosphopyridine nucleotide formed during the oxidation of sorbitol could be rapidly re-oxidized by the addition of acetaldehyde and the diphosphopyridine nucleotide-specific alcohol dehydrogenase from yeast. The amount of keto-sugar formed from sorbitol in the presence of the sperm enzyme was determined colorimetrically[4] and found to be slightly less than the stoichiometrical equivalent of reduced diphosphopyridine nucleotide.

The partially purified sorbitol dehydrogenase prepared from spermatozoa appears to be similar in its mode of action to the enzymes previously obtained from the rat liver[5] and male accessory organs[6,7]. At the optimal *p*H (8·6) the observed zero-order rate of the oxidation catalysed by the sperm enzyme was highest with D-sorbitol and decreased in the order L-iditol > D-xylitol > D-ribitol > D-mannitol. Glycerol, *meso*-inositol, *i*-erythritol and L-arabitol were not oxidized. As regards the reverse reaction, namely, the reduction of various sugars to the corresponding polyols, only fructose, and to a smaller extent, sorbose, were reduced. D-Glucose, D-mannose, D-ribose and 2-desoxy-D-glucose were not reduced, while L-xylose was reduced only very slightly.

The chemical equilibrium in the oxido-reduction shown by the equation favours much more the formation of sorbitol from fructose than the reverse process. In intact spermatozoa, however, the steady state of the reversible conversion of sorbitol to fructose must depend closely on the actual ratio between diphosphopyridine nucleotide and its reduced form present within the sperm cells. This ratio in turn must be related to the rates at which the various metabolic processes catalysed by diphosphopyridine nucleotide proceed in the semen. Among the oxidizable substrates present in semen, fructose and sorbitol occur in particularly large but, at the same time, variable concentrations. It is conceivable, therefore, that the respective levels of fructose and sorbitol in semen influence the ratio between the oxidized and reduced form of diphosphopyridine nucleotide as governed by the sorbitol dehydrogenase in spermatozoa.

We wish to thank Dr. R. Davies for help in performing experiments with the magnetostriction transducer, Dr. A. Walton for collection of semen, and Drs. F. Isherwood and N. K. Richtmyer for gifts of iditol.

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Specificity of Agglutinins in Milk

Heinemann and Glenn[1] observed that certain bacteria were agglutinated in milk serum and concluded that this was possibly related to the germicidal action of milk. Chambers[2] made similar observations but could find no correlation between agglutination and germicidal action. Hobbs[3] examined a variety of milk organisms and attributed the clumping effect of milk on some of them to agglutinins which were probably non-specific. More recently, Wright and Tramer[4] demonstrated that certain organisms noted for slow acid production in activity tests of cheese starters were agglutinated in heat-treated milk. The lag in acid production was shown to be due not to agglutination but to the removal of the agglutinated organisms by the rising cream.

A number of fast and slow acid-producing streptococcal cultures were examined in this Laboratory for agglutination in raw whole milk, and in all cases the 'slow' cultures were shown to be agglutinated. To establish whether agglutination was specific, absorbing antigens were prepared by sterilizing cultures of the test organisms in papain-digested milk with ethylene oxide. After centrifuging, the absorption test was carried out by resuspending the cells in low-count raw whole milk and incubating at 52° C. for 1 hr. These milks were then inoculated at the rate of 10 per cent with standardized inocula of the test organisms and acid production determined after incubation at 30° C. for 6 hr. by titration with *N*/9 sodium hydroxide to the phenolphthalein end-point. Specificity of agglutination was further demonstrated by a ring test using coloured antigen[5]. Results are shown in Table 1.

Table 1. SPECIFICITY OF CERTAIN AGGLUTININS IN MILK

Medium	Lactic acid (per cent)				Ring test	
	*C*10 Fast strain	*ML*1 Slow strain	*KH* Slow strain	*DR*7 Slow strain	*C*10	*ML*1
Autoclaved whole milk	0·82	0·66	0·78	0·75	—	—
Raw whole milk (RWM)	0·89	0·33	0·42	0·34	—	+
RWM plus absorbing antigen :						
*C*10	0·89	0·38	0·52	0·37	—	+
*ML*1	0·85	*0·69*	0·50	0·38	—	—
KH	0·86	0·40	*0·66*	0·36		
*DR*7	0·85	0·34	0·48	*0·44*		

The marked increase in acid production by the slow cultures *ML*1 and *KH* when grown in milk previously absorbed with homologous antigen is clear evidence of specificity. The relatively small increase in the case of *DR*7 may be due either to a high agglutinin titre or incomplete absorption by the added antigen. All the slow cultures show a small non-specific increase in acid production in milk treated with absorbing antigen. This, however, is of a quantitatively lower order than that due to specific absorption.

Full details of this work will be published elsewhere.

My thanks are due to Prof. J. M. Vincent and Dr. Y. T. Tchan for their advice, and to Miss Anne Curley for technical assistance.

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Vitamin B_{12} and Cobalt Concentrations in Livers from Healthy and Cobalt-deficient Lambs

During field investigations into cobalt deficiency we collected pasture samples from experimental paddocks at intervals for cobalt analyses, and at the end of the trials made comparisons of the vitamin B_{12} and cobalt concentrations in the livers of healthy lambs not given cobalt, cobalt-dosed lambs, and other groups showing various stages of cobalt-deficiency disease. Results are shown in Table 1.

Assessments of the cobalt status of pastures were based on a previously estimated minimal level considered necessary to satisfy the cobalt requirement

Table 1

Group	Cobalt status of pastures	Lamb data				Liver determinations					
		No. in group	Cobalt dose	Clinical state*	Stage of deficiency*	Vitamin B_{12} (μgm./gm. fresh tissue)		Cobalt (μgm./gm. dry weight)		B_{12} Co/total Co (ratio)	
						Range	Mean	Range	Mean	Range	Mean
A	Adequate throughout	12	None	Normal	Healthy	0·39–1·1	0·65	0·08–0·16	0·11	0·7–1·0	0·8
B	Low, increasing to adequate	10	7 mgm./lamb/week	Normal	Healthy	0·32–0·96	0·58	0·27–0·60	0·35	0·1–0·5	0·3
C	Low, increasing to adequate	11	None	Normal†	Recovered	0·19–0·60	0·31	0·05–0·12	0·08	0·4–0·9	0·6
D	Low throughout	15	None	Unthrifty	Moderate to severe	0·026–0·097	0·062	0·02–0·06	0·03	0·1–0·6	0·4
E	Low throughout	10	None	Moribund or dead	Extreme	0·008–0·068	0·036	0·02–0·08	0·03	< 0·1–0·4	0·2

* At slaughter or death. † Unthrifty two months previously.

of lambs[1]. The stage of deficiency for each group was assessed partly from pasture cobalt status but mainly from changes in weight or deaths. Vitamin B_{12} was extracted from livers by steaming with cyanide[2] and assayed with *Lactobacillus leichmannii*[3]. Cobalt concentrations in pasture and liver samples were determined by a nitroso-*R*-salt colorimetric method[4]. B_{12} cobalt/total cobalt ratios were calculated from vitamin B_{12} values converted to a dry-weight basis and the cobalt content (4·3 per cent) of the vitamin.

Results for groups *A* and *B* show that vitamin B_{12} concentrations in the livers of healthy lambs exceeded 0·30 μgm./gm. Since lambs in group *C* acted as controls to those in group *B* it is apparent that cobalt dosing approximately doubled the mean vitamin B_{12} concentration. From results for group *C* it appears that a mean vitamin B_{12} value of about 0·30 μgm./gm. can be consistent with a recent history of cobalt-deficiency disease. Results for groups *D* and *E* show that definite cobalt deficiency disease was associated with livers in which vitamin B_{12} concentrations were less than 0·10 μgm./gm. Although the ranges of vitamin B_{12} values for groups *D* and *E* overlapped, the mean for the latter group was only about half that for the former. Corresponding mean cobalt values were, however, the same for both groups. This suggests that vitamin B_{12} assays reflect more closely than do cobalt estimations differences between acute cobalt deficiency causing death and lesser degrees of deficiency.

B_{12} cobalt/total cobalt ratios for livers from group *A* show that most, and in some cases virtually all, of the cobalt in the livers of healthy lambs not receiving cobalt was in the form of vitamin B_{12}. In contrast, most of the cobalt in the livers of cobalt-dosed lambs (group *B*) tended to be in some form other than vitamin B_{12}. This seems best explained as due to inability of the rumen organisms to convert more than a small fraction of the dosed cobalt to vitamin B_{12}. A comparison of the ranges and means of B_{12} cobalt/total cobalt ratios for livers from groups *C*, *D* and *E* with corresponding results for group *A* suggests that cobalt deficiency results in a greater reduction of vitamin B_{12} cobalt than of non-vitamin B_{12} cobalt and that the magnitude of this effect is dependent upon the severity of the disease. Similar results from British work (Phillipson, A. T., Porter, J. W. G., Ford, J. E., and Holdsworth, E. S., private communication) support this conclusion.

Details of these experiments and of others concerning the diagnostic use of vitamin B_{12} determinations will be submitted to the *New Zealand Journal of Agricultural Research* for publication.

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Ingestion of Ethylenediaminetetraacetic Acid and the Effect on Life Span of Irradiated and Control *Habrobracon* Females

The effect of chelating agents on recovery and longevity of irradiated animals has aroused considerable interest. Versene-type compounds are used for the decontamination of radioactive areas and internally for treatment of poisoning by heavy metals[1,2]. Mouse injections have resulted in improved post-irradiation survival[3], whereas cytological studies on plant cells have demonstrated that treatment with ethylenediaminetetraacetic acid (EDTA) prior to irradiation increases the yield of radiation-induced chromosome aberrations[4].

During a study of the genetic damage induced in the reproductive tissues of *Habrobracon* females by chelating agents and X-irradiation[5], considerable information was obtained on the life-span of treated females. The results of five such experiments will be reported here.

Freshly eclosed virgin *Habrobracon* females were starved for 3–5 days prior to feeding, or until dorso-ventral flattening of the abdomen was clearly visible. Groups of females were then fed either from a saturated sugar solution (controls), or from a stock solution of the disodium salt of ethylenediaminetetraacetic acid (0·1 *M*), which was further diluted with saturated sugar solution to ensure palatability. After single feedings, females were placed in Stender dishes and provided with host larvæ of *Ephestia kuhniella*, which the females parasitize. Host larvæ were replenished daily. Females were maintained under optimum conditions without further treatment for the remainder of their life-span.

Table 1. EFFECT OF INGESTED ETHYLENEDIAMINETETRAACETIC ACID AND X-IRRADIATION ON MEAN LIFE-SPAN OF *Habrobracon*

Experiment	Treatment	Mean longevity (days)	Standard error of mean.
A	Controls	27·5	1·94
	2,500 r.	27·1	2·08
	0·09 *M* EDTA	16·3	2·74
	Both*	9·11	2·82
B	Controls	22·8	2·75
	2,500 r.	22·0	1·08
	0·075 *M* EDTA	16·5	2·37
	Both*	12·4	2·49
C	Controls	24·1	1·85
	1,530 r.	25·1	0·34
	0·075 *M* EDTA	10·03	1·55
	Both*	9·82	0·44
D	Controls	22·6	1·71
	2,500 r.	19·9	2·84
	0·075 *M* EDTA	6·5	4·11
	Both*	10·1	1·75
E	Controls	25·7	1·3
	0·075 *M* EDTA	12·4	1·9
	0·025 *M* EDTA	21·0	1·5

* 'Both' indicates combined EDTA + X-ray treatment.

Results are shown in Table 1. It is apparent that X-rays had no effect on the reduction of life-span below that of the controls. Previous studies[6] have shown that *Habrobracon* females are highly radio-resistant when life-span reduction is measured. However, ethylenediaminetetraacetic acid feeding alone consistently decreased the average life-span of females below that of controls in every experiment. This difference is highly significant. Irradiation in addition to ethylenediaminetetraacetic acid ingestion tends to lower the life-span even more (experiments *A* and *B*), but the difference between irradiated and non-irradiated groups, both fed ethylenediaminetetraacetic acid, is not significant. It appears that the ethylenediaminetetraacetic acid meal is the most important determining factor in the reduction of life-span.

Following an ethylenediaminetetraacetic acid meal the death toll is greatest during the first few days. In order to differentiate between a poisoning effect and a true reduction of average life-span, all the results reported in Table 1 for control and ethylenediaminetetraacetic acid-fed females were recalculated omitting deaths occurring during the first two days after treatment. Results of such calculations indicate that the life-span of ethylenediaminetetraacetic acid-fed *Habrobracon* females is still significantly lower than that of control females. Thus ethylenediaminetetraacetic acid feeding does not act as a poison resulting in the death of a large number of treated animals during the first day and having no effect on the survivors of the first 48 hours, but rather it reduces the life expectancy of adult females at all times during the life-span.

Each of the 75 females comprising experiment *E* were weighed before and after feeding on a Roller–Smith precision balance. The amount of food ingested ranged from 0·015 mgm. to 0·505 mgm. Correlation coefficients (r values) for the relation between the amount ingested and the subsequent life-span showed there was no significant correlation ($r = -0·3041$) between the amount ingested and life-span in the group fed with 0·075 *M* ethylenediaminetetraacetic acid. In the group fed with 0·025 *M* ethylenediaminetetraacetic acid there was a slight positive correlation between the amount ingested and the life-span ($r = 0·4903$). This may be attributed to the fact that the most avid eaters are generally more vigorous. It is important to note that concentrations of ethylenediaminetetraacetic acid as low as 0·025 *M* will reduce the average life expectancy of a group of *Habrobracon* females.

The cause of death is unknown, but it seems unlikely that it resulted from chromosomal effects since, unlike vertebrates, adult insects are not dependent upon continued mitotic activity for the maintenance of the life processes. Ethylenediaminetetraacetic acid is known to alter or inactivate enzymes which are involved in oxidative or phosphorylative metabolism[7,8]. Many enzymes have metal ions as co-factors, and it is likely that chelation of metal ions by ethylenediaminetetraacetic acid would result in death due to metabolic failure.

Observations on a large number of females indicate that death subsequent to an ethylenediaminetetraacetic acid meal follows a pattern of progressive inactivation. Movement and activity are often noticeably decreased within a few hours after feeding. Once the female becomes inactive, recovery has not been observed, and death is inevitable. Females may remain in a quiescent, coma-like stage for as long as 12–24 hours before probing fails to elicit further response.

Ingested ethylenediaminetetraacetic acid enhances the radiation effect when fertility or dominant lethals are the criterion of damage[5], but the combination of treatments does not shorten the life-span in a synergistic manner.

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Phenylketonuria in the Rat associated with Decreased Temporal Discrimination Learning

IN the course of other investigations[1] in which tyrosine was injected intraperitoneally it was noted that the level of phenylalanine hydroxylase in the liver of rats was diminished to about one-third the normal value. Since tyrosine added *in vitro* does not inhibit this enzyme activity[2], the results were taken as evidence of product inhibition of enzyme synthesis. It was reasoned that added dietary tyrosine would decrease the enzyme formation and therefore lower the amount of phenylalanine being oxidized to tyrosine; the excess phenylalanine would then be transaminated to phenylpyruvate. Other workers[3] had already shown that phenylalanine added to liver slices would also inhibit the oxidation of tyrosine to acetoacetate and fumarate. It seemed worth while therefore to feed various combinations of tyrosine and phenylalanine in order to evaluate metabolic alterations in the rat. Initial experiments with commercial rat food plus 5 per cent L-tyrosine and 5 per cent DL-phenylalanine resulted in the death of newborn or suckling animals when this diet was fed to the pre-parturient and lactating mothers. The same diet caused death when fed to 21-day-old animals, although animals of the same age grew normally when fed 5 per cent of either amino-acid alone. Reduction of the levels to 2·5 per cent of each amino-acid (and in a later experiment to 3·75 per cent each) caused no difficulty since animals fed this diet gained weight at a rate comparable to that of rats on the commercial diet alone. The methods used for the amino-acid analyses and for enzyme assays have been previously listed[1]. The urinary and blood data are given in Table 1, and the enzymatic data concerned with phenylalanine and tyrosine metabolism are given in Table 2.

The enzymatic results substantiate the initial hypothesis that tyrosine feeding inhibits the production of phenylalanine hydroxylase. The decrease of phenylalanine hydroxylase in animals on the high phenylalanine diet may also in part be explained by the marked inhibition of the activity of this enzyme by high levels of phenylalanine[2]. The tyrosine transaminase activity was measured at a time when the initial increase in activity to be expected on a high tyrosine diet had already subsided[4]. The values for tryptophan peroxidase-oxidase and histidase, two amino-acid catabolizing enzymes which have no connexion with phenylalanine or tyrosine metabolism, were substantially the same in all groups of experimental and control animals.

It had been shown by Linn and Knox[4] that in the case of experimental alcaptonuria produced by the feeding of 5 per cent L-tyrosine in the diet the effects were transitory and lasted for only one month, after which time the excretion of homogentisate fell off. It would appear from our data on urine that the excretion of phenylpyruvate was similar to that of homogentisate and that the effect was maximum one month after the diet was started. In most of our experiments the urines were collected two to three months after initiation of the abnormal diets, so that we may have missed the period of even greater effect. Nevertheless, significantly higher amounts of phenylpyruvate and homogentisate were excreted by most of the experimental animals as compared with the controls.

Table 1

Diet	Plasma (mgm./100 ml.)		Total urinary excretion (mgm./day)	
	Tyrosine	Phenylalanine	Phenylpyruvate	Homogentisate
Normal (5)*	2·5	1·6	1·2	0·1
5 per cent L-tyrosine (5)	3·4	1·3	0·8	0·4
5 per cent DL-phenylalanine (5)	4·8	2·8	19·0	2·8
2·5 per cent each L-tyrosine and DL-phenylalanine (5)	7·4	2·8	3·9	0·9
3·75 per cent each L-tyrosine and DL-phenylalanine (5)†	—	—	54·6	59·8

* The numbers in parentheses denote the number of animals in each group.

† The urines from this group of animals were collected one month after being placed on the experimental diet, while the urines of the other groups were collected after two to three months on the diet (see text).

Table 2

Diet	μMoles product formed per gm. dry weight of liver per hr. at 38° C.			
	Tyrosine (α-ketoglutarate) transaminase	Phenylalanine (pyruvate) transaminase	Phenylalanine (α-ketoglutarate) transaminase	Phenylalanine hydroxylase
Normal (5)*	466±67†	313±29	325±37	24·9±4·4
5 per cent L-tyrosine (5)	313±46	381±24	386±37	0·9±0·9
5 per cent DL-phenylalanine (5)	301±57	348±38	345±21	1·9±0·4
2·5 per cent each L-tyrosine and DL-phenylalanine (5)	694±88	304±45	422±37	8·1±1·1

* The numbers in parentheses denote the number of animals in each group.

† Standard error of the mean.

In phenylpyruvic oligophrenia in humans in which the enzyme phenylalanine hydroxylase is absent[5], decreased intelligence is usually observed concomitant with high urinary excretion of phenylpyruvate. While no single test qualifies as an established measure of rat intelligence, the temporal discrimination test offers advantages of efficiency, reliability and relative independence from sensory and motor capacities. In this test, a response of licking a dry dipper was rewarded by the delivery of water on a 2-min. 'fixed interval' schedule[6]. Temporal discrimination was revealed by positively accelerated licking responses within a 2-min. interval as judged from graphic records which were obtained electronically. Eight normal rats and eight rats the diet of which contained 2·5 per cent tyrosine and 2·5 per cent phenylalanine were tested for eight to twelve days under the condition of water deprivation. The frequency of appearance of positive acceleration on days six, seven and eight, expressed as the percentage of the number of intervals showing any responses, averaged 82·9 per cent for normal rats and 46·8 per cent for treated rats. The standard errors of the means were 2·6 and 9·3 respectively. Days on which no responses occurred were excluded from this calculation; their inclusion, however, would increase the difference between groups. Student's *t*-test gave significant differences between groups at less than the 0·01 level. Therefore, animals which had been on a 2·5 per cent L-tyrosine and 2·5 per cent DL-phenylalanine diet had less phenylalanine hydroxylase in the liver, excreted more phenylpyruvate in the urine and showed marked retardation in temporal discrimination learning.

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Deoxyribonucleic Acid Content of the Nuclei in the Adrenal Cortex of the White Rat

We have already demonstrated a close relation between the deoxyribonucleic acid content of the nucleus and the functional activity of the cell in the thyroid of the white rat[1]: stimulation inducing an increase, inhibition a decrease of the nuclear deoxyribonucleic acid content.

In the present experiments we have examined whether there is a similar correlation for the adrenal cortex, and whether the localization of a decrease of the nuclear deoxyribonucleic acid content after functional depression by various exogenous steroid hormones supports one of the theories of the histophysiology of the adrenal cortex: the migration theory[2] or the theory of specific functional zoning[3].

Male rats, 7 months old, were used. Observations were made on two series of white rats. In the first the nuclear deoxyribonucleic acid content was assayed in five rats receiving 5 mgm. hydrocortisone daily for two weeks, and in five controls. In the second series the measurements were made respectively on five rats receiving daily doses of 5 mgm. cortisone, in five rats receiving 5 mgm. deoxycortisone acetate, and in five controls. In both series the rats were killed at the same time, their adrenals removed and fixed in a mixture of 40 per cent formol, 96 per cent alcohol and acetic acid (20 : 75 : 5, v/v). After simultaneous fixation and dehydration, and embedding and staining by the Feulgen reaction, the deoxyribonucleic acid content of individual nuclei was measured by the histophotometrical technique of Lison[4].

In every adrenal cortex of the second series 50 nuclei were measured in four different layers: the zona glomerularis, the zona fascicularis externa, the zona fascicularis interna and the zona reticularis. In the first series, however, 100 nuclei were measured in every layer, while no measurements were made in the zona fascicularis interna.

The results of the measurements and of the statistical computations are shown in Tables 1 and 2. The parameters are expressed as the pool of the results of every experimental group. The detailed values for the individual rats will be published elsewhere.

All statistical calculations were performed after logarithmic transformation, as the logarithms of the individual values, and not the values themselves, are normally distributed. The null hypothesis was tested by Student's t-test. We took $P \leq 0{\cdot}01$ as the test of significance: a larger value would be useless since it would be smaller than the experimental error.

Table 1*

		$\bar{x}$	$\log \bar{x}$	s	$s_{\log \bar{x}}$	n
Controls	Zona glomerularis	779	2·891	0·068	0·003	474
	Zona fascicularis ext.	758	2·879	0·063	0·002	490
	Zona reticularis	694	2·841	6·046	6·002	485
Hydrocortisone	Zona glomerularis	782	2·892	0·063	0·002	478
	Zona fascicularis ext.	694	2·841	0·015	0·002	493
	Zona reticularis	678	2·837	0·071	0·003	494

* See ref. 4 for symbols, etc.

Table 2*

		$\bar{x}$	$\log \bar{x}$	s	$s_{\log \bar{x}}$	n
Control	Zona glomerularis	1,042	3·017	0·088	6·006	250
	Zona fascicularis ext.	1,041	3·018	0·018	0·001	250
	Zona fascicularis int.	912	2·959	0·066	0·004	250
	Zona reticularis	886	2·947	0·026	0·001	250
Deoxycortisone	Zona glomerularis	982	2·992	0·086	0·007	250
	Zona fascicularis ext.	989	2·995	0·072	0·004	250
	Zona fascicularis int.	941	2·973	0·065	0·004	250
	Zona reticularis	895	2·961	0·071	0·004	250
Cortisone	Zona glomerularis	1,017	3·007	0·083	0·005	250
	Zona fascicularis ext.	931	2·968	0·019	0·001	250
	Zona fascicularis int.	898	2·953	0·064	0·004	250
	Zona reticularis	864	2·936	0·019	0·001	250

* See ref. 4 for symbols, etc.

In the control rats, the same mean values were found in the zona glomerularis and zona fascicularis externa. In the zona fascicularis interna and zona reticularis, however, the mean value of the nuclear deoxyribonucleic acid content was significantly lower ($P < 0{\cdot}001$).

After treatment with hydrocortisone the deoxyribonucleic acid content in the zona glomerularis did not change ($0{\cdot}8 > P > 0{\cdot}7$). In the zona fascicularis externa, however, a significant decrease of the nuclear deoxyribonucleic acid was noticed ($P < 0{\cdot}001$). In the zona reticularis this treatment has no influence on the nuclear deoxyribonucleic acid content ($0{\cdot}2 > P > 0{\cdot}1$). Administration of cortisone had a similar result: no influence on the zona glomerularis ($0{\cdot}2 > P > 0{\cdot}1$), the zona fascicularis interna ($0{\cdot}3 > P > 0{\cdot}2$) and the zona reticularis ($0{\cdot}05 > P > 0{\cdot}02$), but there was a decrease in the deoxyribonucleic acid content in the zona fascicularis externa ($P < 0{\cdot}001$).

The results obtained with deoxycorticosterone-acetate were different. The deoxyribonucleic acid content decreased not only in the zona fascicularis externa ($P < 0{\cdot}001$) but also in the zona glomerularis ($0{\cdot}01 > P > 0{\cdot}001$). That in the zona fascicularis interna ($0{\cdot}05 > P > 0{\cdot}02$) and in the zona reticularis ($0{\cdot}6 > P > 0{\cdot}5$) did not change.

These experiments suggest that there is a relation between nuclear deoxyribonucleic acid content and cell activity in the adrenal cortex. As the localization of the decrease of the deoxyribonucleic acid content depends on the kind of hormone administered, our measurements support the idea of functional zoning of the cortex. Indeed, cortisone and hydrocortisone induce a decrease in the zona fascicularis externa: this observation supports the theory of a specific glucocorticoid function of this zone. Deoxycortisone induces a decrease in both the zona glomerularis and the zona fascicularis externa, which supports the theory of a mineralocorticoid function of the zona glomerularis[5]. Our results, however, suggest that this function is not the exclusive property of the zona glomerularis, but belongs also to the zona fascicularis externa. This conclusion also agrees with recent biochemical investigations, demonstrating the presence of aldosterone in these two layers[6].

These investigations were aided by a grant from the Belgian National Foundation, for Scientific Research. I express also my gratitude to the S.A.

Ciba for providing me with the hormones used in the experiments.

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Separation of Mixtures of Œstrogens in Urinary Extracts using Gradient Elution Chromatography

IN the course of studying the metabolism of œstradiol-4-^{14}C in human mammary cancer, a method of separating mixtures of œstrogens was developed. The method consists of gradient elution chromatography on silica gel with progressively increasing concentration of ethyl acetate in benzene. Separation of mixtures of œstrogens on columns impregnated with alkali[1] was considered potentially detrimental to labile œstrogen metabolites. Other schemes, such as chromatography of œstrogen methyl ethers on alumina[3], were likewise considered inadequate to demonstrate subtle œstrogen metabolic differences without risking either partial decomposition or ease of subsequent identification of metabolites. With the system which has been devised, the separation of a synthetic mixture of œstrogens is complete, and excellent recoveries are obtained. The slight variation in retention volumes is presumably due to lack of temperature control. While the capacity of the columns for separating synthetic mixtures has not been determined, microgram amounts of radioactive œstrogens in urinary extracts weighing 250 mgm. have been successfully separated on 2 gm. columns.

The procedure is as follows: the mixture to be separated is applied in benzene solution to 2 gm. of silica gel (Davison Grade 923, 100–200 mesh, washed with methanol, dried at 140° overnight) in a column 15 cm. × 5 mm. internal diameter, prepared as a slurry. When insoluble in benzene, the residue is applied by adsorbing from an acetone (or other suitable solvent) solution on to sufficient silica gel to form a dry, free-pouring powder on removal of solvent. The dried powder is diluted with benzene and redried twice and then carefully applied to a prepared column containing a head of solvent sufficient to avoid formation of air bubbles. Should any bubbles be visible, they may be removed by agitating the extreme top of the prepared column with a stirring rod. A 500-ml. amber bottle (reservoir) containing 300 ml. of ethyl acetate–benzene (1 : 1) is connected to an identical bottle containing 300 ml. of benzene (magnetically stirred) by means of a siphon tube, so that the solvent-levels are kept equalized. A stop-cock along the siphon facilitates filling the tube. A glass tube terminating in a ball joint with an inner seal is used to connect the solvent in the mixing chamber to the column. Since the vessels are of equal diameter, the rate of outflow from the mixing chamber is equal to twice the rate of inflow, and a linear concentration gradient is obtained[2,4,5]. Three-ml. fractions (collected with an automatic fraction collector) are convenient eluate volumes.

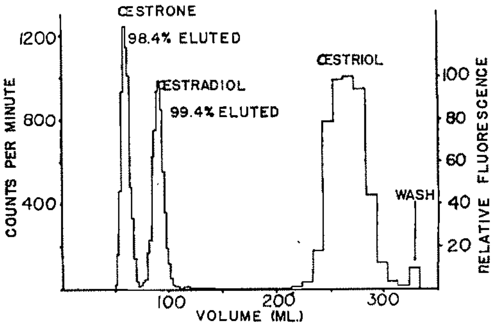

Fig. 1. Separation of a pure synthetic mixture of œstrone, œstradiol and œstriol

The results of a typical separation of a synthetic mixture of œstrone-16-^{14}C, œstradiol-4-^{14}C and œstriol, without urinary extract, are shown in Fig. 1. The first two peaks have been measured radiochemically and the third fluormetrically (relative to the fraction with maximum fluorescence which was designated 100 per cent).

A typical separation which has been obtained with a urinary extract (after enzymatic hydrolysis) from a patient with mammary carcinoma following administration of œstradiol-4-^{14}C, is shown in Fig. 2. The results of paper chromatographic analysis of the material in each radioactivity maximum are shown below each region. This efficient method of separating mixtures of radioactive œstrogens in urinary extracts has also been applied to tissue extracts with comparable success. The applicability of this method to the routine determination of mixtures of non-radioactive œstrogens in various biological media has not been investigated.

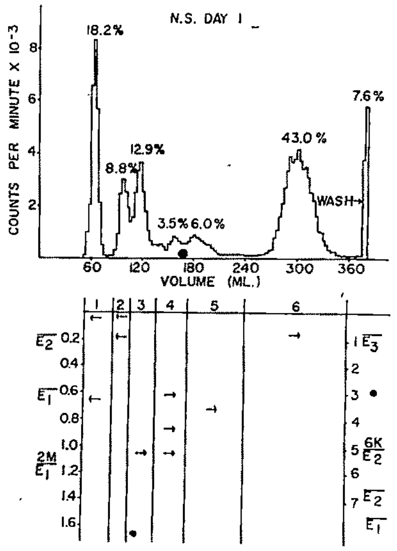

Fig. 2. Separation of urinary extract of patient N.S., day 1, following administration of œstradiol-4-^{14}C. Paper chromatographic mobilities of standards and systems used are indicated to the left and right of each series: left, heptane/methanol; right, benzene/50 per cent aqueous methanol. Direction of arrows at various mobilities designate systems used. Abbreviations are: E_1, œstrone; E_2, œstradiol; E_3, œstriol; 2 $M - E_1$, 2-methoxyœstrone; 6 $K - E_2$, 6-ketœstradiol

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'Crossing' Paper Electrophoresis for the Detection of Immune Reactions

Grassmann and Hübner[1] have pointed out the possibility of applying their continuous paper electrophoresis to the detection of loosely bound molecular compounds. The example they gave was a pair of dyes, orange II and methylene blue. These substances were introduced continuously on to a hanging paper at two separate points. They ran down vertically due to gravity and at the same time migrated horizontally towards each other under the influence of the applied electrical field. It was anticipated that the procedure would be applicable not only to the molecular compounds of dyestuffs but also to antigen–antibody complex formation. However, simpler methods have been devised for the antigen–antibody reaction[2–4].

We have succeeded in simplifying and improving the procedure of Grassmann and Hübner merely by making use of ordinary paper electrophoresis. The substances to be tested are applied not as spots but as streaks drawn obliquely to each other (crossed or not crossed). The angle between the streaks remains the same during electrophoresis, but the two lines cross over, since their mobilities differ. (The procedure may thus be called the 'crossing' paper electrophoresis.) The moving force in the direction at right angles to the electric field is not gravity but the difference in the mobilities and the geometry of the lines of the substances. The final result, however, is the same as is obtained by continuous paper electrophoresis.

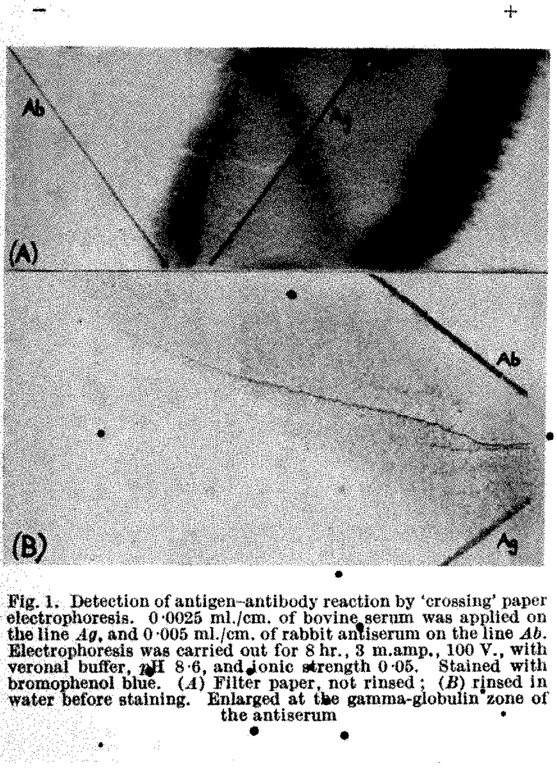

Fig. 1. Detection of antigen–antibody reaction by 'crossing' paper electrophoresis. 0·0025 ml./cm. of bovine serum was applied on the line *Ag*, and 0·005 ml./cm. of rabbit antiserum on the line *Ab*. Electrophoresis was carried out for 8 hr., 3 m.amp., 100 V., with veronal buffer, *p*H 8·6, and ionic strength 0·05. Stained with bromophenol blue. (*A*) Filter paper, not rinsed; (*B*) rinsed in water before staining. Enlarged at the gamma-globulin zone of the antiserum

By this method, the antigen–antibody reaction has been demonstrated on filter paper. As can be seen from Fig. 1, rabbit antiserum (anti-bovine serum) ran ahead and the antigen (bovine serum) ran after. Gamma-globulin of the antiserum was overtaken by the following antigen proteins and crossed over. Thus several lines of precipitates formed gradually alongside the γ-globulin, down to the crossing points of the antigens with it. If the electrophoresis is carried out two-dimensionally, antibody containing γ-globulin was crossed over on a different stretch with each antigenic protein. The ultimate results are almost the same as those obtained by the immunoelectrophoresis of Grabar. The advantages of 'crossing' paper electrophoresis over immunoelectrophoresis are first its simplicity, and second the reduction of material and time needed.

A detailed report and other applications will appear elsewhere.

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Mechanism of Oxidative Phosphorylation

THE phenothiazine tranquillizer chlorpromazine has the following actions: (1) It inhibits electron transport between reduced diphosphopyridine nucleotide and cytochrome *c* in appropriate systems; the efficiency of the coupled phosphorylation is not affected. (2) Chlorpromazine is not effective in mitochondria treated with water or in non-phosphorylating reduced diphosphopyridine nucleotide – cytochrome *c* reductase systems. (3) Chlorpromazine prevents the stimulation of respiration in systems deficient in adenosine diphosphate by 2 : 4 dinitrophenol (Table 1). (4) It causes some stimulation of respiration in mitochondrial systems deficient in inorganic phosphate, but not a maximal stimulation (Table 1), without causing any detectable increase in the level of inorganic phosphate. (5) It inhibits powerfully the exchange reaction phosphorus-32 – adenosine triphosphate[1], under conditions in which electron transport cannot be affected (Table 2). (6) It has no effect on succinate – cytochrome *c* reductase in any system.

These findings are interpreted to mean that chlorpromazine inhibits electron transport between reduced diphosphopyridine nucleotide and cytochrome *c* by inhibiting an intermediate in oxidative

Table 1. EFFECT OF CHLORPROMAZINE AND 2 : 4 DINITROPHENOL ON SYSTEMS DEFICIENT IN ADENOSINE DIPHOSPHATE AND PHOSPHATE

Additions	Chlorpromazine (2×10^{-4} *M*)	Oxygen uptake (μ atm.)	
		Deficient in adenosine diphosphate	Deficient in phosphate
Nil	–	4·5	1·1
Nil	+	3·6	2·1
2 : 4 Dinitrophenol ($3 \cdot 3 \times 10^{-5}$ *M*)	–	8·1	6·0
2 : 4 Dinitrophenol ($3 \cdot 3 \times 10^{-5}$ *M*)	+	3·1	3·6

System: ATP, 0·0017 *M*; KCl, 0·025 *M*; $MgSO_4$, 0·0067 *M*; cytochrome *c*, 2×10^{-5} *M*; L-glutamate, 0·01 *M*; inorganic orthophosphate, *p*H 7·2, 0·01 *M* in adenosine diphosphate-deficient system and 0·0017 *M* in phosphate-deficient system. *Tris* buffer, *p*H 7·2 at 0·067*M*. Mitochondria in 0·25*M* sucrose, 1·0 mgm. nitrogen. Final volume, 3·0 ml. Temperature, 38° C. Gas phase, air. Incubation time, 10 min.

Table 2. EFFECT OF CHLORPROMAZINE ON THE EXCHANGE REACTION PHOSPHORUS-32–ADENOSINE TRIPHOSPHATE

	Counts/min. incorporated into adenosine triphosphate	Inhibition (per cent)
Control	3,150	Nil
Chlorpromazine (2×10^{-4} *M*)	1,460	54

System: ATP, 0·0017 *M*; inorganic orthophosphate buffer, *p*H 7·2, 0·0033 *M*; $MgSO_4$, 0·0067 *M*; KCl, 0·025; *tris* buffer, *p*H 7·2, 0·03 *M*; versene, 10^{-3} *M*; phosphorus-32 equivalent to 15,000 counts/min. added. Time of incubation, 15 min. Temperature, 20° C. Specific activity of phosphorus-32, 1,000 counts/min./μmole.

phosphorylation at a point prior to that which is sensitive to 2 : 4 dinitrophenol. We suggest, for example, a modification of the scheme of Chance and Williams[2], as follows:

$$
\begin{array}{ll}
(1) & B + iP \rightleftharpoons B.P \\
(2) & AH_2 + B.P \rightleftharpoons A + BH_2 \sim P \\
(3) & BH_2P + X \rightleftharpoons X \sim P + BH_2 \\
(4) & X \sim P + ADP \rightleftharpoons ATP + X \\
(5) & BH_2 \sim P \rightarrow BH_2 + iP \\
(6) & X \sim P \rightarrow X + iP
\end{array}
$$

In this scheme, AH_2 would represent reduced diphosphopyridine nucleotide and B oxidized flavoprotein. X is the unknown intermediate postulated by Chance. In this scheme chlorpromazine would interfere with reaction (3) and 2 : 4 dinitrophenol with $X \sim P$ of reaction (4). Reaction (5) would be relatively slow, reaction (6) relatively rapid.

These results are being published in full elsewhere[3].

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Separation of Glucose-1-Phosphate and Glucose-6-Phosphate by Paper Chromatography

GLUCOSE-1-PHOSPHATE and glucose-6-phosphate are not readily separated by the solvent systems normally used for the analysis of the naturally occurring phosphoric esters on paper chromatograms (for example, propanol–ammonia–water, *t*-butanol–picric acid–water, etc.[1]). Though very similar in structure, the esters differ in that glucose-6-phosphate has two *cis*-hydroxyl groups available for substitution and the addition of boric acid to some of the solvent systems previously described enables glucose-6-phosphate to be differentiated clearly from glucose-1-phosphate[2].

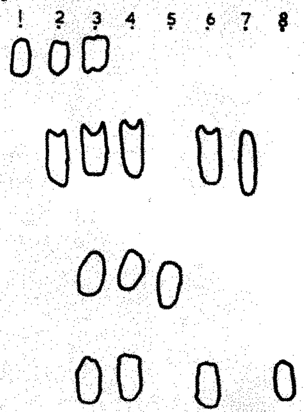

Fig. 1. Chromatogram of phosphoric esters and orthophosphate: (1) fructose-1,6-diphosphate; (2) fructose-1,6-diphosphate + glucose-6-phosphate; (3) fructose-1,6-diphosphate, glucose-6-phosphate, free orthophosphate and glucose-1-phosphate; (4) glucose-6-phosphate, free orthophosphate and glucose-1-phosphate; (5) free orthophosphate; (6) glucose-6-phosphate + glucose-1-phosphate; (7) glucose-6-phosphate; (8) glucose-1-phosphate. Temperature, 20° C.; running time of chromatogram, 48 hr. The paper was equilibrated overnight before the addition of solvent and had been previously washed with acetic acid, distilled water and ammonia (ref. 4)

The addition of boric acid to saturate methyl cellosolve–methyl ethyl ketone–3*N* ammonium hydroxide (7 : 2 : 3 v/v)[3] gives a sharp separation of glucose-6-phosphate from glucose-1-phosphate and from fructose-1,6-diphosphate and inorganic orthophosphate (Fig. 1).

This work was carried out with Dr. F. A. Isherwood at the Low Temperature Research Station, Cambridge.

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Spatial Summation for Heat-Pain

THE report of an experimental study by Greene[1] on this topic reached me too late for reference to be included in my recent communication[2].

Greene used three methods of stimulation. Two of these—needle-scratch and cold immersion—produced no significant amount of spatial summation. In his third method, of thermal radiation, he used a bank of six 500-W. quartz infra-red lamps so arranged as to produce an even field of radiation over a large area, and found a mean temperature difference in pricking-pain sensation thresholds of 1·1° C. as between an area of 7·8 cm.² and one of 2·5 cm.².

This represented a statistically significant degree of spatial summation, but less than that which I reported for the water-heating method, the difference being probably due to two main variations in the procedures used in the two studies. Thus (1) sizes of area stimulated were different, the smallest area I used being about one-third of that used by Greene; (2) 'threshold' judgments of pain differed in definition and in method of determination.

With reference to this second variation, it is well established that a pricking-sensation threshold, such as that used by Greene, varies little among subjects instructed and practised in distinguishing between that and heat sensations. However, as McKenna[3] points out, this is not strictly a 'pain' threshold. It is therefore probable that these two sets of results demonstrate two different, though closely related, aspects of summative process. Thus, Greene's results may indicate a summation of pricking sensation perhaps initiated in the peripheral events, whereas mine may suggest a summation of pain experience which, by implication, would be of central origin.

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Successful Development and Birth of Mice cultivated *in vitro* as Early Embryos

Experimental embryology in mammals is hampered by the comparative inaccessibility of the mammalian embryo. The development of techniques for the cultivation *in vitro* of early mammalian embryos has provided one possible route for experimental interference in the course of embryonic development, through alteration in the conditions of culture and the composition of the culture medium. However, a study of the effects of such experimental interference upon later embryonic development also requires the application of techniques for transplanting early embryos to foster mothers. The first successful attempt to combine the techniques of embryo culture and embryo transplantation was briefly reported by Adams[1]. 16-cell rabbit embryos were incubated for 21½ hr. in Krebs–Ringer bicarbonate containing 2 mgm./ml. bovine plasma albumin, fraction *V* (Armour), during which time cleavage continued at the normal rate. They were then transferred to a recipient female mated 3 days previously to a vasectomized male. One week later there were normal embryos in the uterus of the recipient female, presumably developed from the cultured embryos.

We wish to report an experiment in which viable young were obtained from mouse embryos cultured for 2 days on a synthetic medium during an early stage of embryogenesis, using a culture technique based on that of Whitten[2,3]. As donors, we used immature female mice in which superovulation and mating had been induced by treatment with gonadotrophins[4]. Some of the donors were killed 2½ days after mating; 8–16 cell embryos were recovered from their oviducts and cultured for 2 days at 37° C. in Krebs–Ringer bicarbonate containing 1 mgm./ml. glucose and 1 mgm./ml. crystalline bovine plasma albumin (Armour)[3]. The Krebs–Ringer bicarbonate was prepared from stock solutions on the day that cultures were set up, and gassed with 5 per cent carbon dioxide in air before the glucose and plasma albumin were added. The medium contained no antibiotics or phenol red, but was sterilized by filtration through a sintered glass funnel. The embryos were placed in groups of 4 or 12 into agglutination tubes, each containing 1 ml. of medium. The tubes were closed by silicone bungs after the air above the medium had been replaced by 5 per cent carbon dioxide in air, in order to prevent loss of carbon dioxide and the development of excessive alkalinity. The culture requirements of mouse embryos are more rigorous than those of rabbit embryos, since Adams[1] obtained cleavage without either incorporating glucose in the medium or controlling the *p*H by gassing with carbon dioxide (personal communication), whereas Whitten finds that both procedures are necessary for the development of mouse embryos.

After two days of cultivation, 216/249 (87 per cent) of the mouse embryos had developed into blastocysts. A comparable degree of development takes place *in vivo* in 24 hr., and control blastocysts were therefore recovered from the uteri of the remaining donor animals 3½ days after mating. Control and cultured blastocysts were transferred, following the technique of McLaren and Michie[5], to the uteri of recipient females 2½ days after mating to fertile males. Cultured blastocysts were transferred in the culture medium, and control blastocysts in Pannett and Compton's saline. Of the recipient females which became pregnant, all but two were killed on the sixteenth day of gestation. Since transferred embryos were homozygous for albinism, whereas the recipient females had all been mated to males homozygous for full colour, transferred and native embryos could be distinguished at this stage of development by eye colour. All embryos were individually weighed. The two remaining pregnant females received subcutaneous implants of progesterone to delay parturition and were allowed to proceed to term (19 days), their young being delivered by Cæsarian section.

The results are given in Table 1. The yield of live from cultured embryos (20·4 per cent) proved not to differ significantly from the control yield (21·7 per cent), which was itself similar to that obtained previously by McLaren and Michie[5]. There was a strong indication that the average weight of the cultured embryos was less than that of the control transferred embryos, but on the small numbers available the difference proved not to be significant ($P > 0 \cdot 05$). Even if such a difference exists, it need not indicate any enduring effect of the culture treatment upon subsequent development, since the cultured

Table 1. The Yield of Live Transferred Embryos at the Sixteenth or Nineteenth Day of Gestation in Females which received either Cultured or Control Blastocysts

Mice receiving cultured blastocysts		Mice receiving control blastocysts	
Mouse No.	Yield	Mouse No.	Yield
1	5/9	9	0/9
2	4/11	10	0/11
3	1/9	11	3/12
4	2/11	12	7/17
5	2/16	13	5/20
6	1/12		
7*	0/10		
8*	4/15		
Total	19/93	Total	15/69

Those allowed to proceed to the nineteenth day are marked with an asterisk. The yield is given as the number of live transferred embryos/the number of blastocysts injected into the uterus.

blastocysts may have been at a somewhat earlier stage of development than the controls when transferred.

Only one of the pregnant females allowed to go to term contained cultured embryos. Two of these were successfully fostered on to a newly parturient female. They are at the time of writing four weeks old, and appear in no way affected by their unusual history.

We are indebted to Mr. John Roberts for skilled technical assistance. The work has been made possible by a grant to J. D. B. from the Nuffield Foundation, and a grant to A. M. from the Agricultural Research Council for financial support.

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Measurement of Sap Flow by Heat Transfer

It has been assumed by those who have used a pulse of heat as an indicator to measure the rate of flow of sap in trees[1] that the speed of the sap is identical with that of the heat pulse.

That this assumption is not correct can be shown by obtaining the differential equation for heat transfer in an idealized medium consisting of wood substance perforated by many uniformly spaced, parallel straight tubes through which sap flows at a uniform velocity. If the wall thickness between tubes is about 10μ, this medium will approximate the xylem of a conifer. Since a slab of wood substance (diffusivity, $k = 0{\cdot}004$ cm.²/sec.) 10μ thick will heat up to the temperature of its surfaces[2] in 10^{-4} sec., whereas the time associated with the passage of a heat pulse is of the order of minutes in practice, the structure can be treated as a homogeneous mixture from the point of view of heat transfer.

If a fraction, a, of any plane area perpendicular to the x-axis is occupied by sap streams moving with uniform velocity, u, parallel to the x-axis, then the layer of material bounded by the planes x and $(x + \delta x)$ gains heat at a rate per unit area equal to:

$$- au\rho_s c^s \frac{\partial v}{\partial x} \delta x$$

where ρ_s and c_s are the density and specific heat of sap (water), and v is the temperature. On including this term in the derivation of the normal heat conduction equation, one obtains the equation for combined conduction and convection:

$$k\nabla^2 v = \frac{\partial v}{\partial t} + au \frac{\rho_s c_s}{\rho c} \frac{\partial v}{\partial x} \qquad (1)$$

where k, ρ and c refer to the wet wood, that is, to the wood substance together with the stationary and the moving sap.

This equation is identical in form with the equation for pure conduction in a 'medium' moving in the x-direction with velocity[3]:

$$V = au \frac{\rho_s c_s}{\rho c} \qquad (2)$$

That is, the stationary wood and the moving sap together act like a single medium moving at a speed defined by V, the 'heat-pulse velocity'.

Consider a piece of the xylem of *Pinus radiata* with basic density (oven-dry weight/green volume) 0·37 gm./cm.³, and moisture content (relative to oven-dry weight) of 190 per cent. This has $\rho = 1{\cdot}07$ gm./cm.³ and $c = 0{\cdot}77$ cal./gm./° C. The fraction a is not easy to measure, but if we take $a = 0{\cdot}20$ as a reasonable value, equation (2) gives:

sap speed, $u = 4{\cdot}1 \times$ heat-pulse velocity, V

Due to the difficulty of measuring the fraction, a, we have found it more convenient to express the rate of sap flow as 'sap flux', the volume of sap flowing across unit area of the xylem in unit time. We then have:

$$\text{sap flux} = au = \frac{\rho c}{\rho_s c_s} \cdot V = \rho_b\,(m_c + 0{\cdot}33)\,V \qquad (3)$$

where ρ_b is the basic density of the sapwood, m_c is its moisture content, and 0·33 is the specific heat of oven-dry wood.

From the solution of the normal heat conduction equation, for an instantaneous line source of heat along the z-axis[2], one can write the corresponding solution of equation (1):

$$v = \frac{Q}{4\pi kt} \exp\left[-\frac{(x - Vt)^2 + y^2}{4kt}\right] \qquad (4)$$

A sap flow meter based on this equation has been developed in this laboratory. The heater in its simplest form, which is used for limbs up to about 2 in. in diameter, is a piece of 26 standard wire gauge nichrome resistance wire lying along a diameter through which a current up to 40 amp. is passed for 1 or 2 sec. to provide the heat pulse. The temperature is measured at some distance downstream (usually 1·5 cm.) by means of a Philips 83900 3*K*5 thermistor set in the tip of a 21 standard wire gauge hypodermic needle. The quantity of heat in the pulse is chosen to give a maximum rise in temperature at the needle of about 0·3 deg. C.

It has been found in experiments on *Pinus radiata* that, provided the thermistor is deeper than about 0·5 cm. in the sapwood, so that the effect of loss of heat at the surface is avoided, the curve of temperature rise against time agrees closely with that predicted by equation (4). In cases where the agreement is not perfect, usually at comparatively high heat-pulse velocities, very good agreement has been obtained by assuming a uniform spread of heat-pulse velocities over a certain range. Since, however, the best-fitting uniform-speed temperature – time curve corresponds to a speed close to the average of these different speeds, an analysis based on equation (4) is used in routine measurements.

This analysis gives the heat-pulse velocity, V, and the diffusivity, k, in terms of the relative temperature rises at any three times such that one is the average of the other two. This avoids the necessity of calibrating the temperature recorder or the heater. Charts have been constructed for the cases of times in the proportions 1 : 2 : 3 and 1 : 4 : 7, which enable each curve to be analysed in a few minutes.

Experiments have confirmed that dye travels through the xylem of *Pinus radiata* at speeds up to four times greater than the heat-pulse velocity. Equation (3) has also been verified experimentally.

It should be emphasized that this mathematical analysis applies only to such trees as conifers, which have a fine-structured xylem. The case of hardwoods with coarser xylem which cannot be treated as thermally homogeneous has not yet been analysed mathematically, but it is still to be expected that the stationary wood substance will retard the heat pulse to a speed less than that of the sap. The experimental curves in this case are very like those given by the theory above for a spread in heat-pulse velocities ranging down to zero.

Full details of these investigations will be published in *Plant Physiology*.

I gratefully acknowledge the continuous assistance and advice on all botanical aspects of this work of Mr. K. M. Harrow, Plant Diseases Division, Department of Scientific and Industrial Research, Auckland, New Zealand, who originally suggested the project.

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Effect of Gibberellin on the Extensibility of the Pea Stem

It has been demonstrated[1-5] that an increase in the extensibility of cell wall is involved in the growth-promoting effect of auxin. Hence it is of interest to see if gibberellin has a similar effect.

Excised pieces of etiolated stem of Alaska pea were soaked in 10 mgm./l. solutions of gibberellin (crystalline mixture of gibberellins by Kyowa Fermentation Co.) and of indole-3-acetic acid, at 25·3° ± 0·2° C. The pieces were subjected, in solution, to a longitudinal tension of 2·5 gm., and the increase in distance between two marks on each piece was measured with a cathetometer.

A representative set of results are illustrated in Fig. 1. The piece treated with indole-3-acetic acid shows temporary extension and contraction respectively at loading and unloading, regular elongation following in both cases. The control piece behaves similarly, but with smaller amplitudes. On the other hand, the piece treated with gibberellin scarcely elongates under load; rather it tends to elongate when unloaded.

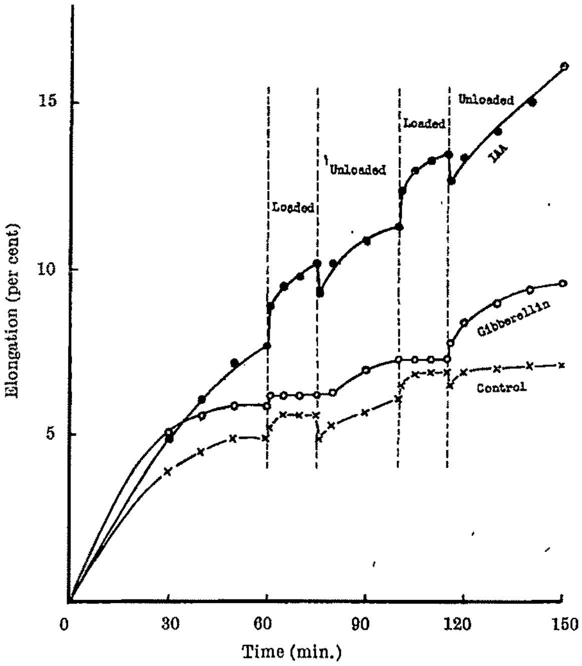

Fig. 1. Changes, due to loading and unloading, of the distance between two marks on a stem piece soaked in water and in solutions of indole-3-acetic acid and of gibberellin

Tagawa and Bonner's method[5] was modified so that the stem piece was bent while it was held in the solution. The stem piece was soaked for 2 hr. in a solution of indole-3-acetic acid (10 mgm./l.) or of gibberellin (20 mgm./l.) or in distilled water, and then a tangential force was applied to one end with a weight. The piece bent as *A B C C′* (Fig. 2). The degree of bending varied considerably from piece to piece. However, a smaller variance was obtained by taking the ratio of the angle increment in the first minute (*A*—*B*) to that in a longer period (for example, *A*—*C′*). This ratio can be called the 'relative incipient bending'. When the force was removed at *C*, the piece unbent to *C D E*, due to its elasticity. The remaining angle, that is *A*—*D* or *A*—*E*, represents the plasticity.

As shown in Table 1, the relative incipient bending is enhanced by treatment with indole-3-acetic acid and is lowered by treatment with gibberellin, as compared with the control. These results show that indole-3-acetic acid makes the stem piece more yielding to an extending force while gibberellin makes it less so. Similarly, the plasticity is increased by indole-3-acetic acid and decreased by gibberellin.

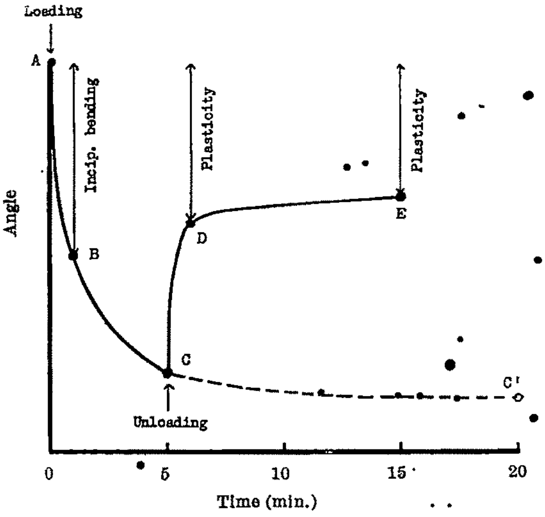

Fig. 2. Diagrammatic representation of process of bending and unbending

Table 1. Relative Incipient Bending and Plasticity of the Pea Stem Piece pretreated with Indole-3-Acetic Acid, Gibberellin or Water for 2 hr.

For *A*, *B*, *C*, *C'*, *D* and *E*, see Fig. 2. Heavy load, 686 mgm.; light load, 456 mgm. Average of five samples and probable error

	Incipient bending $\frac{B-A}{C'-A}$ (per cent)		Plasticity (after heavy loading) (per cent)	
	Heavy load	Light load	$\frac{D-A}{C-A}$	$\frac{E-A}{C-A}$
Indole-3-acetic acid (10 mgm./l.)	—*	67·8 ± 2·5	60·7 ± 1·8	54·7 ± 2·7
Gibberellin (20 mgm./l.)	56·4 ± 3·9	49·3 ± 5·1	51·9 ± 1·3	44·7 ± 1·7
Control	66·6 ± 4·6	56·7 ± 5·4	54·8 ± 2·1	50·9 ± 3·1

* Too much bending occurred within 20 min.

It is therefore suggested that gibberellin has an effect opposite to that of auxin on the extensibility and particularly the plasticity of the stem. Details, together with further studies, will appear elsewhere.

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Effect of Gibberellin on Sunflower Tissue Culture

Recently Nickell[1] reported the effect of gibberellin on several plant tissues grown *in vitro*. The results were generally non-specific. Sunflower petiole crown-gall tissue growth was inhibited rather drastically by 10 p.p.m. of gibberellin, whereas tobacco and sweet clover were somewhat enhanced by it. Schroeder and Spector[2] showed marked increased effect of gibberellin on growth of mature citron explants in the presence of indoleacetic acid, but very limited growth in its absence. The accelerating influence or interaction of indoleacetic acid on other growth factors (for example, kinetin[3]) and gibberellin[4 5] has been a well-observed fact in many experiments and observations relating to correlation of growth factors[6].

In the experiments reported here tissue of sunflower origin[7] was used. The method was similar to that used in former experiments with this tissue[8]. The gibberellin was added to the media containing indoleacetic acid or lacking it to make final concentrations of 0·001 to 1·0 p.p.m. for habituated tissue (H_h), and 0·2 to 200 p.p.m. for tumour tissue (*Pv*). The media (*p*H 6·0) were autoclaved at 20 pounds pressure for 15 minutes. There were 5 replicates at each concentration of gibberellin. The weights were taken after 8 weeks growth.

The results are strongly in agreement with Nickell, indicating a non-specific influence. Tumour tissue appears to be generally inhibited by the addition of gibberellin. There is no significant increase in any of the concentrations. Tumour tissue, as might be expected[8], grows better on medium lacking indoleacetic acid. Habituated tissue shows no response to gibberellin at the relatively low levels used.

Table 1. Growth of Sunflower Tumour Tissue on Gibberellin Cultures 8 weeks old (10–5–58 to 3–7–58). Wet weight (gm.)

Gibberellin (p.p.m.)	GBA* − indoleacetic acid	GBA* + indoleacetic acid
0	1·67	0·62
0·2	0·98	0·31
2·0	0·76	0·51
20·0	0·86	0·79
200·0	0·64	0·39

* GBA consists of Gautheret (½ Knop) medium, Berthelot minor elements and addendum of vitamins, amino-acids, adenine sulphate.

Table 2. Effect of Gibberellin on Habituated Tissue of Sunflower

Cultures 8 weeks old (21–12–57 to 13–2–58). Wet weight (gm.)

Gibberellin (p.p.m.)	GBA + indoleacetic acid
0	0·35
0·001	0·28
0·01	0·32
0·1	0·36
1·0	0·36

These results are similar to those recorded for these same strains of tissues (plus the normal strain of sunflower callus tissue, H_n) grown on the basal media, GBA (see Table 1), with and without indoleacetic acid, in the presence of kinetin at 0·01, 0·1 and 1·0 p.p.m.[9]. In this experiment, also, H_h and H_n showed very little deviation from the controls, especially the normal callus, H_n.

The results of Nickell and those reported here seem to suggest a general principle in plant tissue culture, of the callus type, namely, that when tissue cultures which have been grown for many passages on specific media are subjected to certain new factors, such as gibberellin and kinetin, they no longer adapt or respond as rapidly as do freshly cut explants such as carrots used for certain chemical assays[10] or the citron tissues of Schroeder and Spector. These slices are more like the original tissues *in vivo* where gibberellin especially is most demonstrative in its effects on growth.

I wish to thank Chas. Pfizer and Co., Inc., for supplying the gibberellin.

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Synthesis of Blood Protein by the Fat Body in the Silkworm, *Bombyx mori* L.

The concentration of protein in the blood of insects changes remarkably in the course of metamorphosis[1]. I have shown that the concentration of blood protein increases after the middle period of the last larval instar[2] in the silkworm. It is not yet clear, however, what organ is concerned in the synthesis of blood protein in larval stage, although there are reports by Sissakian and Kuvaeva[3] that

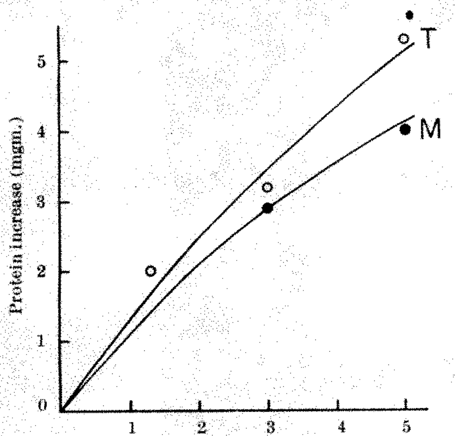

Fig. 1. Increase in the amount of protein in the tissue (*T*) and in the medium (*M*) during *in vitro* protein synthesis by the fat body. Initial amount of protein in the tissue, 34·2 mgm.

blood itself synthesizes the protein in the pupal period of the silkworm. It was demonstrated that the content of protein in the fat body per individual remained almost constant after the middle period in the last larval instar, meanwhile activity to synthesize protein by the tissue was rather high in the same period[4,5]. In order to elucidate the fate of the protein, the following experiments were carried out.

In the first experiment, net synthesis and secretion of protein by the fat body was demonstrated. The fat body of the silkworm, 500 mgm., was incubated in a medium consisting of 1·6 ml. of saline solution (sodium chloride 0·4, potassium chloride 0·05, calcium chloride 0·02, magnesium sulphate 0·01 per cent and phosphate buffer $M/150$, pH 7·0), 0·4 ml. of boiled extract of blood, 20 mgm. of casein acid hydrolysate as amino-acid source and 10 µmoles of adenosine triphosphate, for 1–5 hours at 30° C. After incubation, medium and tissue were separated by filtering through paper and determination of protein content was carried out on both the fractions. The result shown in Fig. 1 indicates that protein content in both fractions increases. The increase was completely inhibited by addition of 2 : 4-dinitrophenol. No disintegration of the tissue seems to occur during the tissue culture in such a short time as five hours. Therefore, it is highly probable that the increase in protein content in both tissue and medium shows the synthesis of protein in the tissue and the secretion thereof into the medium.

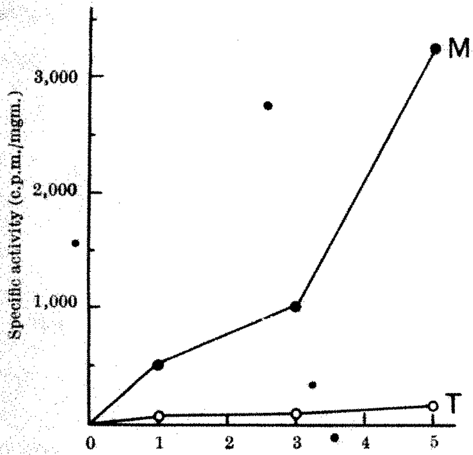

Fig. 2. Increase of the specific activity of protein in the tissue (*T*) and in the medium (*M*) during the *in vitro* incorporation of labelled amino-acids by the fat body

In the second experiment, the incorporation of amino-acids labelled with carbon-14 into protein was investigated to confirm the synthesis and the secretion of protein by the tissue. The reaction was carried out in a medium consisting of 0·8 ml. of saline solution (the same constituent as preceding experiment except that sodium chloride was 0·7 per cent), 0·2 ml. of boiled extract of blood, 1 per cent glucose, 5 µmoles of adenosine triphosphate, 0·5 µc. of labelled amino-acid mixture (isolated from *Euglena* cultured in a carbon-14-dioxide atmosphere), and the 200 mgm. fat body at 33° C. After incubation, medium and tissue were separated as above and fractionated to obtain the protein fraction. Radioactivity in each of the protein fractions was measured by a gas-flow counter and the specific activity calculated (c.p.m./mgm. protein). The radioactivity of substances adsorbed on to the protein was subtracted from the experimental value. As shown in Fig. 2, after five hours incubation the specific activity of the medium protein reaches a level far higher than that of the tissue protein. If the medium protein consists of a part of tissue protein broken down during the incubation, the specific activity of the medium protein should be the same as, or even lower than, that of the tissue protein. This result indicates strongly that the fat body synthesizes and secretes a certain kind of protein.

In the third experiment, the nature of the protein secreted by the fat body was investigated by paper electrophoresis. This was carried out on a strip of Tōyō filter-paper No. 51 for 15 hours at room temperature with a current of 0·5 m.amp/cm. at 200–100 V. using veronal buffer (0·05 M, pH 8·6). The result is shown in Fig. 3. The mobilities of the main

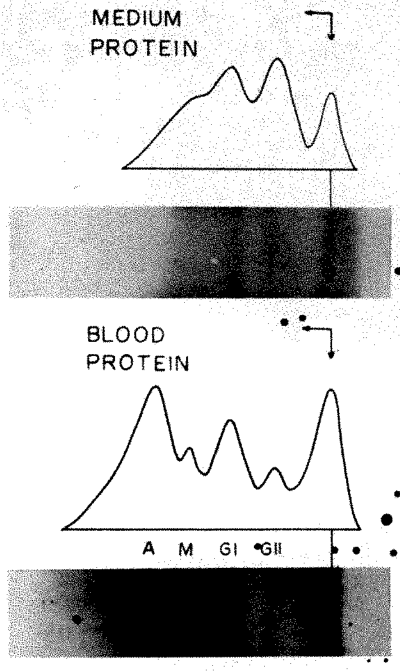

Fig. 3. Paper electrophoretic patterns of medium protein after 5 hr. of protein synthesis *in vitro* by the fat body, and of blood protein at the eighth day of the fifth larval instar

components of the medium protein were similar to those of the globulin components of blood protein. It is generally accepted that blood protein of the silkworm consists of three main components and one less conspicuous component *M*. The former are albumin (*A*) and two globulins (*G* I and *G* II), the *M* component appears only in females at the prepupal stage[6,7]. Furthermore, in blood, the ratio of the two globulin components to the total protein content increases after the middle period of the fifth instar[7].

The rate of increase in quantity of blood protein was about 13 mgm. per individual per day during the later half of the last larval instar. In the first experiment, the increase of protein in the medium after 5 hours *in vitro* corresponds to about 12 per cent of the initial amount of tissue protein. In the silkworm, the amount of protein in the fat body remains almost constant at about 20 mgm. per individual during the second half of the last larval period[4]. Therefore, the quantity of protein secreted by the fat body can be calculated as about 12 mgm. per individual per day, about the same as the increase in blood protein *in vivo*.

From these facts, I propose that the fat body of the silkworm synthesizes globulins and secretes them into the blood circulation in a larval stage, at least in the fifth larval instar.

The molecular weight of the globulin components of blood protein is, however, large according to Oda[8], and the mechanism of secretion of these components of high molecular weight still remains unknown.

I wish to thank Mr. Hiro-o Takeshita and Miss Tomoko Koyasako for technical assistance in this work.

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Effects of Rust Infection on the Carbohydrate Metabolism of Wheat Seedlings

In the course of studies on the nature of resistance of plants to disease, experiments were performed to determine the effect of stem rust (*Puccinia graminis* Pers. f. sp. *tritici* Erikss. and Henn., race 34) infection on the distribution of the carbon-14 of photosynthetically fixed carbon-14 dioxide among the sugars in the wheat varieties Gabo 54 and Little Club. These varieties are resistant (reaction type 1) and susceptible (reaction type 4), respectively, to race 34 of the pathogen.

Seedlings, grown in nutrient solution, were inoculated at the two-leaf stage on both their leaves, while comparable seedlings remained uninoculated to serve as controls. Seven days later, both the inoculated and then diseased seedlings, and the uninoculated healthy controls were placed in an atmosphere enriched with carbon-14 dioxide, in the light, for 1 hr. Immediately afterwards, the first two leaves were extracted with 80 per cent boiling ethanol. They were further extracted with 30 per cent boiling ethanol and finally, in a Soxhlet extractor, with 90 per cent ethanol. The three fractions thus obtained were combined, and the alcohol was removed by vacuum distillation, the chlorophylls by extraction with benzene, and the ionic substances by treatments with ion-exchange resins[1]. The resulting purified sugar solution was analysed by 1-dimensional paper chromatography, using *n*-butanol/acetic acid/water (4 : 1 : 5 v/v/v) as the solvent and Whatman No. 1 filter paper. The chromatograms were irrigated and dried three times before development. The position of the radioactive components on the chromatogram was detected by autoradiography. Sugars were identified by 2-dimensional co-chromatography and by their colour reactions to specific reagents[2].

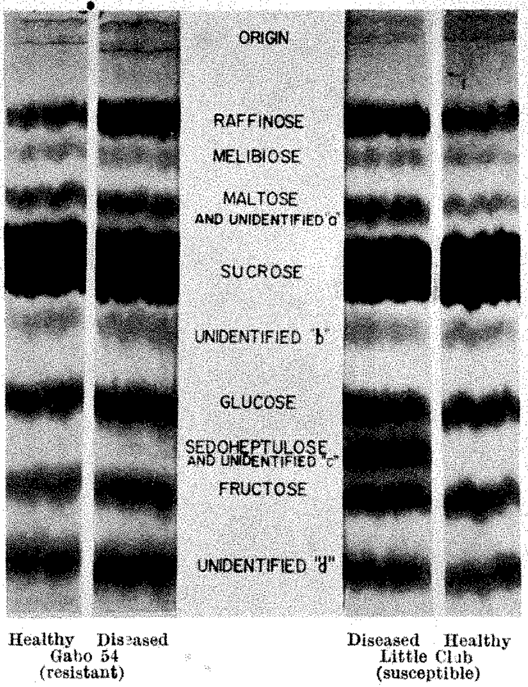

Fig. 1. Autoradiogram of chromatograms of the sugars in healthy and stem-rust infected (diseased) wheat leaves, grown in an atmosphere containing carbon-14 dioxide

At least nine radioactive bands were detected on the chromatograms in all cases (see Fig. 1). The sugars in six of these bands were identified as raffinose, melibiose, maltose mixed with an unidentified compound, sucrose, glucose and fructose. The three other bands, which included the origin, contained unidentified compounds. One additional band was detected on the chromatograms of the extract of diseased leaves of the susceptible variety, Little Club. This band split into two when the paper was irrigated for a longer period of time than that used in preparing the chromatograms of the autoradiogram of Fig. 1. The compound in one of these two bands was sedoheptulose, that in the other band was not identified.

All the sugars that were identified in this work had previously been reported to occur in wheat leaves[3,4], except maltose and sedoheptulose. In view of the fact that infection was light, and as a consequence mycelium and spore production was small, it can be assumed that, except for amounts probably too small to be detected by the method used, all the radioactive sugars detected in leaves occurred in the host cells.

The accumulation of carbon-14 in sedoheptulose in rusted leaves of the susceptible plants was the most striking metabolic alteration caused by infection. However, infection affected also the amount of carbon-14 fixed in the other sugars. In general, the relative radioactivities of the sugars were increased by infection. Sucrose was an exception, its radioactivity being decreased. The relative radioactivities of the sugars as modified by infection, suggestions respecting the biochemical mechanisms responsible for the pathological accumulation of sedoheptulose and alterations in the distribution of carbon-14 among the sugars, and comments on the significance of these results in relation to resistance and susceptibility to rust, will be published elsewhere.

Financial support by the National Research Council and the Colombo Plan Administration in Canada is gratefully acknowledged.

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Induced Resistance of Mice to Infection with *Brucella abortus* 2308 through Vaccination with *BCG*

NON-SPECIFIC factors affecting the immunological state of the host have recently been the subject of many investigations. Some of these were concerned with the increase in resistance to tuberculosis[1-4]. The enhancement of resistance of mice to *B. abortus* infection following vaccination with *BCG* appears not to have been reported so far.

Swiss albino mice weighing 15–18 gm. were used. All immunization and challenge doses were administered intra-abdominally. A group of mice were injected with 0·4 mgm. of *BCG* cells taken from a three-week culture on Petragnani's medium. Another group were injected with 2 mgm. of heat-killed (1 hr. at 70° C.) *BCG* taken from the same medium. Groups of five mice from the animals immunized with living *BCG* were challenged at two, three, four and six weeks after immunization with 0·2 ml. of a suspension of the virulent *B. abortus* 2308, containing 30,000 cells. Groups of five mice from the animals immunized with killed *BCG* were similarly challenged at two and four weeks after immunization. Control groups of five mice were also injected with *Brucellae* and included in the experiment. Seven days after challenge all mice were killed with ether and their spleens removed aseptically. The five spleens of each group were homogenized and suspended in 25 ml. tripticase soy broth. 0·2 ml. of 1 : 10 and 1 : 100 dilutions of this suspension were spread on tripticase soy agar plates. The colonies were counted after four days incubation at 37° C. Table 1 shows the results of this experiment.

Table 2. RADIOACTIVITY (C.P.M.) IN THE SPLEENS OF MICE VACCINATED WITH LIVING OR KILLED *BCG* AND CHALLENGED WITH RADIOIODINATED *B. abortus*

Mice No.	Counts per min. in spleens of			
	Mice vaccinated with living *BCG**	Control mice	Mice vaccinated with killed *BCG*†	Control mice
1	2,588	5,351	1,994	4,610
2	4,658	6,091	4,645	5,808
3	428	2,320	1,225	4,947
4	2,869	4,415	1,501	2,933
5	171	2,667	430	2,766
6	197		1,098	5,955
7			1,604	5,723
8				5,535
Mean counting rate	1,818	4,168	1,785	4,785

* Interval between vaccination and challenge, 34 days. † 19 days.

The number of *Brucella* cells in the spleens of normal mice was 25–300 times larger than that in the spleens of mice vaccinated with living *BCG*. The immunizing effect of killed *BCG* was less marked. However, the spleen counts of mice vaccinated with killed *BCG* were 5–36 times less than those of non-vaccinated controls. Such differences can be regarded as an indication of a marked immune state.

The immunizing effect of *BCG* was confirmed with an additional technique. It was recently reported that following intra-abdominal inoculation, the distribution of killed, radioiodinated *Brucellae* in the organs of specifically immunized mice was strikingly different from that in the organs of normal animals[5]. The spleens of immune mice collected a lower amount of radioactivity than the corresponding organs of the normal animals. Table 2 shows that a similar distribution of *Brucellae* could be induced when *BCG* was used for immunization. Groups of mice were vaccinated with 0·1 ml. of a ten-day 'Tween' albumin culture of *BCG* or with 2 mgm. of heat-killed *BCG* grown on Petragnani's medium. These mice and normal controls were injected intra-abdominally with 0·3 mgm. (~ 100,000 counts per min.) radioiodinated

Table 1. MULTIPLICATION OF *Brucella abortus* 2308 IN THE SPLEENS OF MICE VACCINATED WITH *M. tuberculosis BCG*, 2, 3, 4 and 6 WEEKS PRIOR TO CHALLENGE

BCG cells used for immunization	No. of cells recovered from spleens and protection indices*							
	2 weeks		3 weeks		4 weeks		6 weeks	
	N	*P.I.*	*N*	*P.I.*	*N*	*P.I.*	*N*	*P.I.*
Living	5,675	95	4,500	25	9,000	55	500	300
Heat-killed	15,000	36	—	—	96,750	5	—	—
None (controls)	540,000	—	112,500	—	502,000	—	150,000	—

N = number of cells.

$$* \; P.I. = \text{protection index} = \frac{\text{No. of bacteria in spleens of control mice}}{\text{No. of bacteria in spleens of immune mice}}$$

Brucellae which had been killed with acetone and 6 hr. later the animals were killed, the spleens removed and counted in a scintillation counter.

The counts in the spleens of the vaccinated mice were twice as small as those in the unvaccinated ones. This difference is an indication of immunity. A detailed report will be given later.

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Antituberculous Factors of Milk

Milk and milk-whey have been found to contain one or more anti-tuberculous agents[1]. The administration of milk, milk-whey or the dialysate of the latter which passed through a 'Cellophane' membrane, inhibited the development of experimental tuberculosis in the mouse. The question arises whether an inhibitory influence on the mycobacterium is responsible for this effect. If so, the material obtained from milk should be effective *in vitro*. *In vitro* experiments with milk, milk-whey and its dialysate were therefore performed.

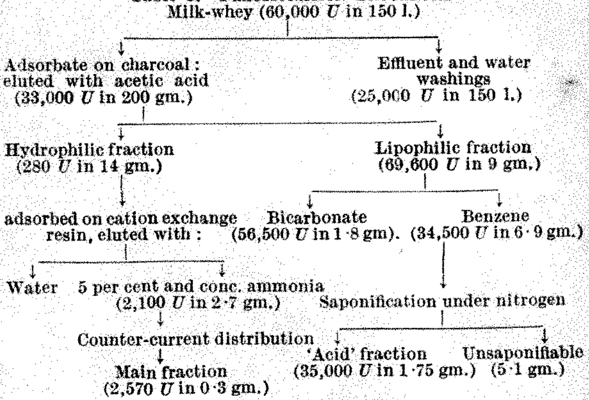
In these tests the material was diluted with Kirchner's medium before Seitz-filtration. When milk, milk-whey or milk-whey dialysate were concentrated *in vacuo* and diluted with the medium to reconstitute their original concentration in the milk, total growth inhibition of *Mycobacterium tuberculosis* strain *H*37*Rv* occurred. No extraneous antiseptics or antibiotics were used in feeding the cattle or in milking or dairying. Inhibitory activity was also found in goats and human milk.

Further experiments, which are summarized in this communication, were attempted in order to concentrate and characterize the active principle from cow's milk.

As a first step, milk-whey was adsorbed on charcoal ('Karborafin', Hrušovské chemické závody). This retained about half the activity, which could be desorbed with glacial acetic acid after a preliminary wash with water. The dry residue of the acetic eluate represented less than 10 per cent of the dry weight of the whey and contained, besides other substances, much lactose, lactic acid and peptides. On fractional precipitation the activity remained largely in the liquid phase up to a concentration of 90 per cent acetone, most of the lactose and peptides of higher molecular weight being precipitated.

Distribution between an acid-aqueous phase and an organic one, such as chloroform, made it possible to separate the inhibiting activity into lipophilic and hydrophilic factors. The lipophilic fraction contains most of the activity (Table 1). When distributed between benzene and an aqueous bicarbonate solution, the activity in the lipophilic fraction separates into two fractions, most of the activity passes into the bicarbonate layer, but some remains in the benzene and cannot even be extracted with 1 *N* sodium hydroxide. The activity which passed into bicarbonate can be re-extracted in an organic solvent after acidification, and thus behaves like an organic acid. Fatty acids of medium chain-length, especially lauric acid, were identified and estimated by reversed-phase paper chromatography[2]. Calculations and comparative inhibition tests showed that the saturated straight-chain fatty acids of medium chain-length, although active against *Mycobacterium tuberculosis*[3], cannot be responsible for more than 1–5 per cent of the activity of this fraction.

Table 1. Fractionation Procedure


Milk-whey (60,000 U in 150 l.)
Adsorbate on charcoal: eluted with acetic acid (33,000 U in 200 gm.)
Effluent and water washings (25,000 U in 150 l.)
Hydrophilic fraction (280 U in 14 gm.)
Lipophilic fraction (69,600 U in 9 gm.)
adsorbed on cation exchange resin, eluted with:
Bicarbonate (56,500 U in 1·8 gm).
Benzene (34,500 U in 6·9 gm.)
Water
5 per cent and conc. ammonia (2,100 U in 2·7 gm.)
Saponification under nitrogen
Counter-current distribution
'Acid' fraction (35,000 U in 1·75 gm.)
Unsaponifiable (5·1 gm.)
Main fraction (2,570 U in 0·3 gm.)

The 'neutral' (more lipophilic) fraction can be saponified by alkali, and after removing the unsaponifiable material an active fraction can be extracted into bicarbonate from benzene. It also contains fatty acids of medium chain-length, but these are no more active than the fatty acids of the other acid fraction.

Most of the growth-promoting substances are concentrated in the hydrophilic fraction, together with the inhibitory principle, and they thus partially mask its activity. Further purification therefore is accompanied by a rise not only of specific activity but also of overall activity (Table 1). Owing to its cationic character the active principle can be retained on a cation exchange column (*FN*, Stalinovy závody, containing sulphonic groups). It is not washed out by water but 5 per cent ammonia begins to elute it. A considerable rise of activity occurs. Further purification is obtained using a counter-current distribution between *n*-butanol and water acidified to *p*H 3.

This hydrophilic factor is not retained on anion exchange resins and therefore differs from the urinary principle described by Björnesjö[4]. The protein lactenin, isolated by Jones[5], can likewise be excluded, but similarity to the basic tissue peptides studied by Dubos[6] and Bloom[7] is possible.

It can thus be concluded that at least three factors inhibitory to the growth of *M. tuberculosis* *H*37*Rv* in a liquid medium are contained in cow's milk-whey. The elucidation of a possible relationship between the substances active *in vitro* and the protective activity of milk-whey in experimental mouse tuberculosis awaits further study.

Concentrates of the hydrophilic factor (1,000 *U*/gm.) (one *U* is defined as the amount per ml. cultivation medium that causes a 50 per cent inhibition of growth in *M. tuberculosis* *H*37*RV*) and of the lipophilic factor (5,000 *U*/gm.) were tested against the following bacteria: *Streptococcus haemolyticus* β; *Staphylococcus pyogenes aureus* (Oxford); *Escherichia coli*; *Pseudomonas aeruginosa*; and *Bacillus subtilis*.

No inhibition was observed up to a concentration of 10 mgm./ml. test solution in plate tests and up to the concentration of 1 mgm./ml. in liquid cultures, thus demonstrating a high antibacterial specificity. The inhibitory activity of the unfractionated concentrate against *Mycobacterium tuberculosis H37Rv* was not removed by the addition of ox serum instead of tween-80 to the liquid medium. (We are indebted to Dr. V. Bydžovský and Mrs. A. Čížková for these results.)

The concentrate was also active against *Mycobacterium tuberculosis* (*H37Rv* and several first cultures) in solid medium according to Löwenstein, but inactive against the *BCG* strain, *Mycobacterium phlei* and *M. smegmatis*. (These tests were performed by Dr. Šula and Dr. Švachulová in the Research Institute for Tuberculosis, Prague.)

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Effect of Total Body Irradiation on Capillary Permeability

It seems to be generally accepted that increased permeability of the capillary wall is one of the basic changes caused by exposure to massive X-irradiation. It must be emphasized, however, that the proofs for this supposition are very inconclusive. Tendency to bleeding and diffuse hæmorrhages may be produced not by increased permeability, but (besides the accompanying hæmatologic disorders) by an increase of capillary fragility, that is of susceptibility to injuries of the capillary wall.

The permeability of capillaries can only be tested by substances passing through their walls by filtration or diffusion. An increase of permeability is indicated by a more rapid passage of these substances, especially of plasma proteins and of colloids in general. Systematic studies on the passage of colloids through the capillary walls in irradiated animals are few. The decrease of plasma concentration depends, however, not only on the transcapillary migration of the colloid molecules but also on the return of the labelled protein by way of the lymphatic channels.

The purpose of the present studies was therefore to investigate the disappearance of labelled plasma proteins from the circulation as well as their transport through the lymphatics after massive total body X-irradiation.

All investigations were carried out on normal mongrel dogs of 8·5–19·5 kgm. body-weight. Animals were subjected to total body X-irradiation ranging from 500 to 700 r., delivered from a Siemens–Stabilivolt therapy unit at dose-rates about 17·6 r./min., other radiation factors being 180 kV., 15 m.amp., 1 mm. copper, and 85 cm. target-skin distance. On the third to the twenty-fifth day after irradiation the dogs were anæsthetized with chloralose (0·1 gm./kgm.) and a polyethylene tube was inserted into the thoracic duct at its junction with the great veins. 1–6 ml. of iodinated human serum albumin (iodine-131 activity 2–3 μc.) and 2–3 ml. of a 0·5 per cent Evans-blue solution were injected intravenously and plasma and lymph samples collected. In control experiments the same procedure was performed in 9 normal dogs.

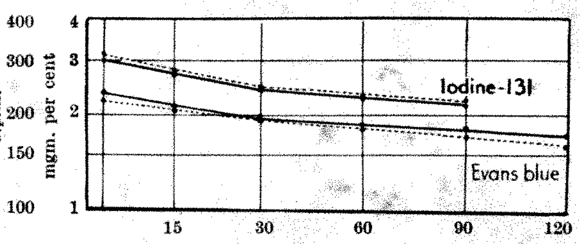

Fig. 1. Concentration in blood plasma of injected Evans-blue and albumin labelled with iodine-131 in normal and in irradiated dogs with thoracic duct fistula. ———, Normal dogs; – – – –, irradiated animals

Besides the well-known decline in erythrocyte count and an extreme fall of the leucocyte count, a slight diminution of plasma protein concentration (1·1 gm. per cent; standard deviation, $s = 1{\cdot}1$; $P = 5$ per cent) was detected. In contrast to the results of Ferrell, Turner and Overman[1] a decrease of circulating plasma volume ($-15{\cdot}1$ per cent; $s = 8{\cdot}7$) occurred. This decrease was, however, roughly parallel with the loss of body-weight (-16 per cent; $s = 7{\cdot}7$). As regards the disappearance of the tagged protein and of Evans-blue injected, there was no significant difference between the irradiated animals and the controls (Fig. 1). The fraction of albumin labelled with iodine-131 and of Evans-blue leaving the circulation in one minute (k) calculated after Wasserman and Mayerson[2] was practically identical in both groups of animals. (In the first 30 minutes the value of k was 0·00669; $s = 0{\cdot}00180$

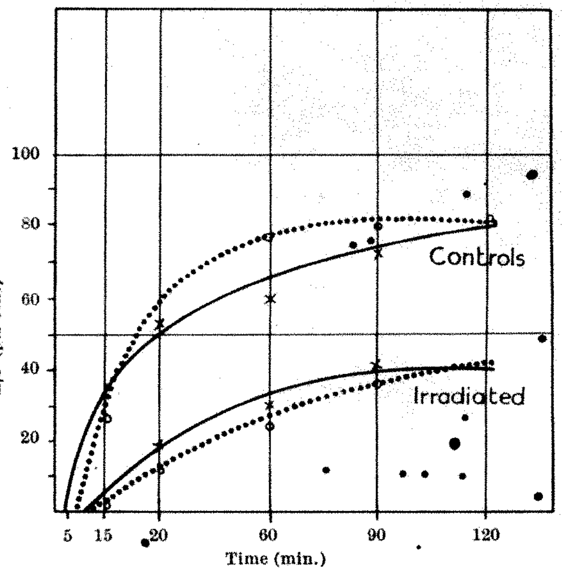

Fig. 2. The effect of irradiation on the equilibration between plasma and lymph of injected labelled protein. L/P, Concentration in lymph/concentration in plasma as percentage. ......, Evans-blue; ———, albumin labelled with iodine-131

for Evans-blue; 0·00775, s = 0·00433 for albumin labelled with iodine-131 in the irradiated; and 0·00699, s = 0·433; 0·653; s = 0·00302 respectively in the normal dogs. Between 30 and 90 minutes after injection the respective values were 0·00191, s = 0·00072; and 0·00245, s = 0·00154 in the irradiated; 0·00223, s = 0·00138; and 0·00226, s = 0·00077 in the normal dogs for Evans-blue with respect to albumin labelled with iodine-131; the differences were not significant.) The concentration of Evans-blue and labelled albumin in the lymph in the irradiated dogs definitely rose more slowly than in the controls, and 90–120 minutes after the injection attained only 42·3 (Evans-blue) and 39·9 (labelled albumin) per cent of the plasma concentration, whereas in the controls the relative concentrations were 82·1 and 78·8 per cent (Fig. 2). Due also to a decrease in flow of lymph, the back-transport of the labelled protein from the tissue spaces to the circulation was greatly reduced. During the first hour the leakage in the normal dogs amounted to 26·1 (s = 4·6) per cent of injected Evans-blue and 18·7 per cent (s = 5·5) of albumin labelled with iodine-131. In the irradiated animals the respective values were 21·1 (s = 3·1) per cent; the differences were not significant. On the other hand, during the same period, the thoracic duct in the normal animals transported 4·96 (s = 2·66) per cent of injected Evans-blue and 3·93 (s = 1·66) per cent of labelled albumin, whereas in the irradiated animals the lymphatic returns were respectively only 0·46 (s = 0·30) and 0·39 (s = 0·24) per cent of the injected amount.

In 4 out of 7 irradiated animals the lymph contained a considerable amount of erythrocytes (49,000–625,000 per mm.^{3}).

In our experiments on irradiated animals no increase in transport of colloidal molecules through the capillary walls could be detected. The return of the extravasated protein molecules by way of the lymphatic channels was, however, greatly reduced. The appearance of hæmorrhagic manifestations as well as of red blood cells in the lymph detected by Furth *et al.*[3] and observed also by us indicates marked capillary damage, but, as we have already pointed out, this phenomenon has no direct connexion with the passage of colloidal molecules. In normal circumstances plasma proteins leave the circulation at a constant rate, passing across pores of molecular dimensions. As colloidal molecules cannot re-enter the capillaries the magnitude of this transcapillary exchange can be estimated by investigating the lymphatic transport. Porker, Chaikoff and Reinhardt[4] established that in the dog approximately half of the total plasma protein traverses the thoracic duct per day. In view of the large transcapillary exchange of protein under normal circumstances, and the comparatively large total pore surface area, the leakage of protein through the openings in the damaged capillary wall may presumably be neglected.

Our results suggest that the return of extravasated protein through the lymphatic channels is greatly reduced in irradiated animals.

A decreased lymphatic transport of tagged protein must result (without any acceleration of passage through the capillary walls) in a quicker decrease of its plasma concentration, as observed by Wish *et al.*[5]. In our investigations, however, the main lymphatic trunk being divided, this phenomenon could not be detected. As protein leaving the circulation can return by way of the lymphatic channels only, delayed lymphatic transport leads to considerable loss of plasma protein.

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Origin and Connexions of the Central Nutrient Mass in *Lumbricus* Spermatogenesis

Examined by electron microscopy, the central nutrient mass around which spermatogonia up to spermatozoa are attached is seen to be non-nucleated and to contain mitochondria (*M*, Fig. 1) and various types of nutrient spheres and vacuoles. All spermatic cells are connected to this central mass by bridges (*J*, Fig. 1) which become much attenuated as the spermatic cells develop. The central nutrient mass is developed in the middle of the spermatogonial syncytium during early growth stages of the spermatocytes, and through these bridges all cells draw upon this store equally for their development into spermatozoa, thus being kept in step.

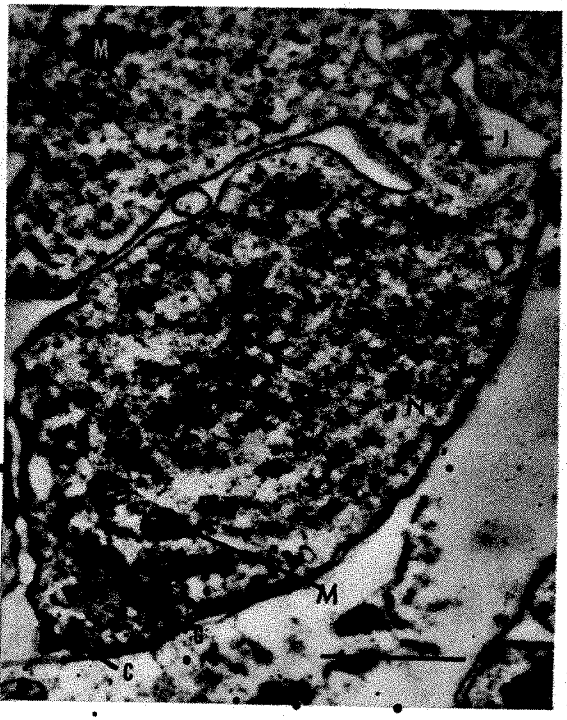
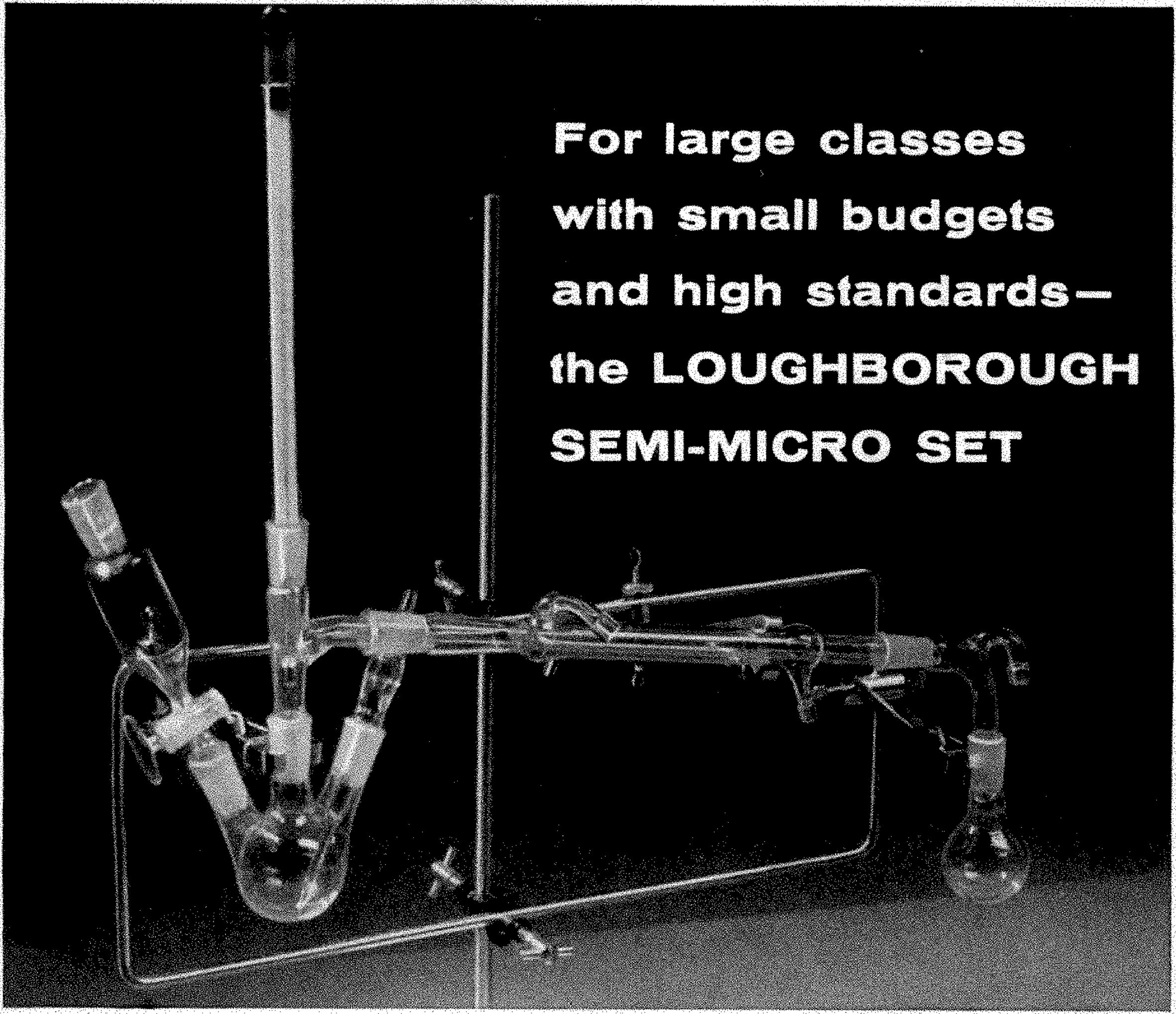


Fig. 1. (× 19,000)



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THE STORY OF THE PERSIAN BEER BARREL

The fungus stereum subpileatum breaks down the cell structure of the wood

The mind of the beer drinker boggles indeed when he finds his pint smells of cheap scent . . . and that is what might have happened to many a man in the Spring of 1957, when he ordered X's Best Bitter.

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In Fig. 1 the oriented spermatid contains the mitochondrial nebenkern (N) at the posterior end of the nucleus, the proximal centriole lying in between. The distal centriole and the flagellum are at (C) and the Golgi body at (G). A further account of this work is being published elsewhere.

This work was performed in part under the auspices of the U.S. Atomic Energy Commission.

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Synaptic Transmission in a Sodium-free Medium

The observation of Lorente de Nó[1], that small frog axons ("Et fibres") are excitable in media where the sodium is totally replaced by certain quaternary ammonium ions, has since been extended to crustacean muscle fibres[2], frog A-fibres[3,4], frog spinal ganglion cell-bodies[5] and mammalian striated muscle[6,7] and nerve[8] fibres. Such findings suggested that the membrane of muscle fibres and neurones in different species was capable of maintaining excitability when the external sodium was replaced by a favourable cation possessing a tetracovalent nitrogen atom. The purpose of the present study was to determine whether synaptic transmission could also be maintained in sodium-free media. It is well known that the membrane characteristics of the junctional region are somewhat different from those possessing the conductile activity, since the post-synaptic membrane produces graded responses by the action of the transmitter released from the pre-synaptic membrane. It was previously reported[9] that in the frog spinal ganglion cell-bodies hydrazinium ion was the most favourable substitute for sodium ion; the action potentials of cell-bodies being very similar to those observed in normal Ringer. An attempt to replace sodium ion by hydrazinium ion was quite successful; the neuromuscular transmission was restored in the sodium-free hydrazinium solution.

Nerve sartorius preparations of frogs (*Rana pipiens*) were used. The sodium-free hydrazinium solution contained 2 mM potassium chloride, 1·8 mM calcium chloride with various amounts of hydrazine (Eastman) and sufficient sucrose to maintain isotonicity. Both the hydrazine base and the final solution were adjusted to pH 6·5 with hydrochloric acid.

Neuromuscular transmission of the nerve sartorius preparations was completely blocked when soaked in a sodium-free 224 mM sucrose solution (containing 2·0 mM potassium chloride and 1·8 mM calcium chloride) for 30–40 min. In addition, the individual muscle fibres lost their electrical excitability, and the sensitivity of the end-plate membrane to directly applied acetylcholine was greatly depressed as measured by the absence of any contraction upon the application of acetylcholine in concentrations less than 10^{-5} gm./ml. No end-plate potential could be recorded by applying nerve stimulations. The disappearance of the end-plate potential caused by lack of sodium is mainly due to a decrease in the amount of released acetylcholine rather than a decrease in the sensitivity of the end-plate membrane to it[10]. It was quite certain, therefore, that the activity of the terminal endings of motor nerve fibres disappeared in a sodium-free sucrose solution, although the residual electrical activity of nerve twigs innervating the sartorius muscle was usually still detectable.

A surprising restoration of neuromuscular transmission occurred in the preparations which were first immersed in sucrose for 60–90 min. and then in a solution containing 80–100 mM hydrazine. Normal muscle contractions were induced by nerve stimulations about 10–20 min. after re-immersion in these solutions. Meanwhile, the resting potential of the muscle fibres maintained a normal value, and propagated muscle action potentials, similar to those observed in normal Ringer, were produced by intracellular direct stimulations. However, the values of the threshold of muscle fibres were considerably larger than those obtained in normal Ringer. With nerve stimulations the end-plate potentials could be recorded from the end-plate regions, and the propagated muscle spikes were observed from muscle fibres. The muscle contractions, however, disappeared shortly after continuous nerve stimulations (1/sec.) were applied for 10–20 min., although the electrical activity of the nerve twigs innervating the sartorius muscle and the sensitivity of the end-plate membrane were maintained (visible muscle contractions were produced by direct applications of acetylcholine in concentrations of 10^{-7}–10^{-8} gm./ml.).

These experimental results demonstrated that, in addition to the activity of the motor nerve axon[4], the activity of the muscle fibres with the post-synaptic membrane and of the motor terminal endings with the pre-synaptic membrane were also maintained in the sodium-free hydrazinium solution. Although a trace of sodium may be retained around the junctional regions, it is not likely that the concentration of sodium was sufficient to maintain transmission[10]. It seems as if the hydrazinium ion is acting in exactly the same way as the sodium ion does upon the post- and pre-synaptic membrane. The experimental evidence[11,12] obtained from spinal ganglion cell-bodies, however, seems to exclude this possibility. Recently, synaptic transmission in the sympathetic ganglion of frogs has also been found to be maintained in a sodium-free hydrazinium solution.

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Effect of Tryptophan Analogues on Reversion of a Tryptophan-requiring Strain of *Escherichia coli*

Two years ago, Witkin[1] reported experiments indicating that protein synthesis was essential for the 'fixation' of the mutagenic state induced by ultra-violet irradiation. More recently, Doudney and Haas[2] have shown that at least two processes are involved in the production of bacterial mutations by ultra-violet irradiation; the first process results in fixation of the mutation into the genome, the second involves a removal of the mutagen produced by the radiation. We would like to report experiments that indicate that protein synthesis is involved in the actual utilization or degradation of the mutagen produced by ultra-violet irradiation.

Washed broth cultures of a tryptophan-requiring mutant of *Escherichia coli* strain *B/r* (isolated in this laboratory) were used in these experiments. Reversion of this mutant to the prototrophic condition was determined by plating cell suspensions on Petri dishes containing minimal medium. Ultra-violet irradiated cells, irradiated in buffer, were incubated for 1 hr. at 35° in 10 ml. of liquid medium of the indicated composition contained in centrifuge tubes (Table 1), they were then collected, washed and re-incubated for 1 hr. as indicated after which they were plated on minimal medium *C*[3]. Survival was determined by plating on minimal medium *C* supplemented with tryptophan. The amino-acid mixture (AA) was prepared according to Witkin[1] and contained no tryptophan. DL-Tryptophan, DL-5-methyl tryptophan and DL-tryptazan were added to give a concentration of 40 μgm./ml. The tryptazan was a gift from Dr. H. R. Snyder.

It is readily apparent that we have obtained the effect reported by Witkin; a large increase in the number of prototrophs was obtained by incubation immediately following irradiation in a medium rich in amino-acids. It is also apparent that the 'mutagen' produced by ultra-violet is stable when washed cells are incubated in medium with no tryptophan added or when 5-methyl tryptophan is added (Table 1). The mutagen disappears, however, following incubation with DL-tryptazan.

In order to make certain that the tryptazan effect is not due to a differential toxicity of this compound on the prototrophs, the following experiment was performed (Table 2). Irradiated cultures were incubated for 1 hr. in medium containing an amino-acid mixture with tryptophan added, after which the cultures were washed, incubated in minimal medium with amino-acids plus tryptazan for 1 hr., rewashed and plated on minimal medium *C*. There is no inhibitory effect of tryptazan on cells which have already been fixed by preliminary incubation in amino-acids plus tryptophan.

Table 1. EFFECT OF POST-IRRADIATION INCUBATION ON THE YIELD OF PROTOTROPHS. $6 \cdot 1 \times 10^8$ TRYPTOPHAN-REQUIRING *E. coli* PER ML. WERE IRRADIATED WITH ULTRA-VIOLET TO GIVE A SURVIVAL OF $4 \cdot 6 \times 10^7$ CELLS/ML. (7 PER CENT). ALL TREATMENTS WERE IN MINIMAL MEDIUM *C* SUPPLEMENTED AS INDICATED

	Post ultra-violet treatment	Viable cells plated	Mutants/plate	Prototrophs/10^6
	None	$4 \cdot 6 \times 10^6$	3·3	0·72
a	1 hr. AA, no tryptophan	$5 \cdot 2 \times 10^5$	1·0	2
b	As in (*a*), followed by an additional hour in AA plus tryptophan	$7 \cdot 7 \times 10^5$	97·6	127
c	1 hr. in AA plus tryptophan	$6 \cdot 3 \times 10^5$	126	200
d	As in (*c*), plus an additional hour in fresh medium of the same composition.	$8 \cdot 2 \times 10^5$	144	175
e	1 hr. in AA plus methyl tryptophan	$3 \cdot 8 \times 10^5$	6	16
f	As in (*e*), but followed by an additional hour in AA plus tryptophan	$5 \cdot 9 \times 10^5$	96·6	164
g	1 hr. in AA plus tryptazan.	$7 \cdot 0 \times 10^5$	0	0
h	As in (*g*), but followed by an additional hour in AA plus tryptophan	$5 \cdot 7 \times 10^5$	11	19

Table 2. EFFECT OF 5-METHYL TRYPTOPHAN AND OF TRYPTAZAN ON PROTOTROPH VIABILITY. $3 \cdot 5 \times 10^9$ CELLS PER ML. WERE IRRADIATED WITH ULTRA-VIOLET TO GIVE A SURVIVAL OF $4 \cdot 6 \times 10^8$ VIABLE CELLS PER ML. (13 PER CENT)

	Post ultra-violet treatment	Viable cells plated	Mutants/plate	Prototrophs/10^6
	None	$4 \cdot 6 \times 10^7$	1·3	2·9
a	1 hr. in AA plus tryptophan	$3 \cdot 1 \times 10^7$	198	640
b	As in (*a*), followed by 1 hr. in AA plus tryptazan	$2 \cdot 5 \times 10^7$	188	750
c	As in (*a*), followed by 1 hr. in AA plus 5-methyl tryptophan	$3 \cdot 4 \times 10^7$	159	470
d	As in (*a*), followed by 1 hr. in AA plus tryptophan	$2 \cdot 2 \times 10^7$	227	1,003

It is apparent that there is a striking difference in the effect of the tryptophan analogues 5-methyl tryptophan and tryptazan. In the presence of methyl tryptophan the 'mutagen' is stable, with tryptazan it disappears. We feel that this difference is related to the different use made of these analogues by *E. coli*. Tryptazan is activated by the amino-acid activating enzyme[4] and is incorporated into the protein of *E. coli*[5]. Methyl tryptophan is neither activated nor incorporated and in fact inhibits the activating enzyme. However, the proteins formed by the incorporation of analogues are often inactive biologically[6].

We suppose that the 'mutagen' produced by ultra-violet irradiation is consumed in some way as a result of the protein synthesis necessary for mutation fixation. Formation of an abnormal protein, with tryptazan substituted for tryptophan, results in disappearance of the mutagen, but without the production of mutations for which active protein is necessary. The mutagen is stable when protein synthesis is not possible, as in the presence of 5-methyl tryptophan.

We would like to take this opportunity to thank Drs. M. Lieb, E. Witkin and C. Doudney for making available a large amount of their results prior to publication. This investigation was supported in part by contract *AT*(30-1)1138 between Syracuse University and the U.S. Atomic Energy Commission.

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Genotypic Control of Crossing-Over on the First Chromosome of *Drosophila melanogaster*

WHILE it has long been known that crossing-over varies both with the environment[1] and with maternal stage of development[2], relatively little is known about its genotypic control. Such information as exists is derived chiefly from the cytological observation of chiasma-frequency[3], although some is also available from the early work on *Drosophila melanogaster* by Gowen[4] and by Detlefson and Roberts[5]. Since cytological observations can rarely provide detailed information about the distribution of points of exchange along the lengths of single chromosomes, it was thought worth while to examine the genotypic control of crossing-over by the genetical study of recombination.

The experiment was designed to determine the effect of the autosomal genotype on the recombination between three marker genes on the X-chromosome, namely, white-eye (w), miniature wing (m) and bar-eye (B) (Fig. 1). Two long-inbred lines of *D. melanogaster*, Oregon (O) and Samarkand (S), together with their reciprocal F_1's, were chosen for this purpose. Using a balanced lethal stock CyL/Pm ; H/Sb, the marked X-chromosome was introduced into each of these inbred lines. The design of the experiment was that of an orthogonal three-point linkage test[6], and the estimation of recombination frequencies for each genotype in each of four environments (15, 20, 25 and 28° C.) was undertaken by Fisher's product method.

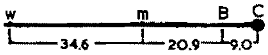

Fig. 1. Genetic map of the X-chromosome of *D. melanogaster*, showing the position of the three marker-genes. w, white-eye ; m, miniature wing ; B, bar-eye ; and C, centromere

The results of the experiment are shown in Fig. 2, from which three points emerge. First, Oregon has, on average, a higher frequency of recombination than Samarkand ; and the F_1, while consistently exceeding the mid-parent, nowhere exceeds both parents significantly, except in the case of the proximal segment at 25° C. The difference between the inbred lines is highly significant ($P < 0{\cdot}001$), as is that between the lines on one hand and their F_1's on the other. Since both the inbred lines may be regarded as virtually homozygous, it is clear that the variation of recombination-frequency with genotype is not solely determined by the degree of hybridity of the genotype, but also by its genic content. Nevertheless, it is equally clear that crossing-over can be related here to the heterozygous genotype, since the F_1's exceed the mid-parent in this respect. This is similar to the situation in rye as shown by Rees and Thompson (ref. 3*d*).

Secondly, the regional sensitivity of crossing-over to change in the environment varies markedly with genotype. Thus for Oregon and Oregon × Samarkand, the effect of change in the environment is more marked in the proximal than in the distal segment (when change is measured by the *maximum* difference between environments), and this is similar to the results of previous experiments[7]. Samarkand and Samarkand × Oregon, however, behave differently, for their frequency of recombination varies much less proximally than it does distally. The reason for this difference between the genotypes is not clear, since the marked X-chromosome is approximately the same in all. On the other hand, the similarity of the reciprocal F_1's with their respective maternal lines strongly suggests that the maternal cytoplasm determines, to some extent at least, the pattern of response of crossing-over to change in the environment. If, as Mather[8] suggests, high sensitivity to the environment is a property of the heterochromatic regions of the chromosome, then it may be that the distribution of heterochromatin varies with genotype. There is some evidence from certain Orthoptera that this can occur[9]. On the other hand, high sensitivity to the environment may not be confined to the heterochromatic segments of the chromosomes. A further possibility is that the difference between Oregon and Oregon × Samarkand, and Samarkand and Samarkand × Oregon in regional sensitivity may be due to differences in the distribution of their chiasmata along the length of the X-chromosome. The present observations provide no means of distinguishing between these hypotheses.

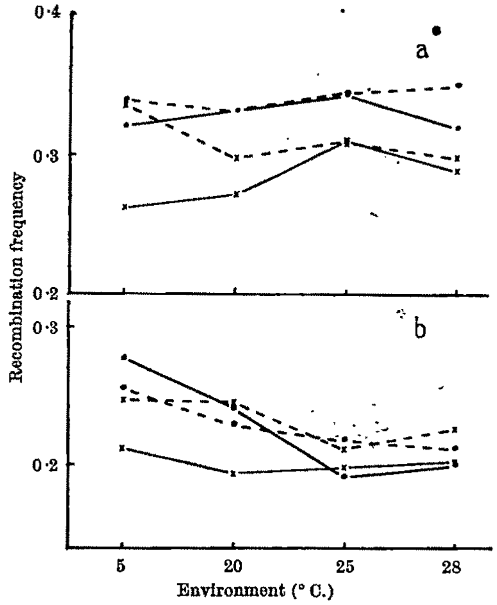

Fig. 2. Variation of recombination frequency of the (a) distal (w–m) segment and (b) proximal (m–B) segment with change of environment.

Oregon, ——·——; Samarkand, ——×——;
Oregon × Samarkand, ---·---; Samarkand × Oregon, ---×---

Thirdly, while there is a highly significant difference ($P < 0{\cdot}001$) between reciprocal F_1's in their frequencies of recombination between w and m, the difference between them is negligible in the proximal segment. The difference in the distal region is in the direction expected if maternal cytoplasm is active in determining crossing-over in this segment. But if maternal cytoplasm were the sole determinant, then we should expect the curves relating recombination to environment in the F_1's to be the same as those of their maternal parents. With the exception of the 25° C. environment, this expectation is clearly not realized. It is therefore evident that, in addition to the cytoplasm, the genotype must be having its effect in determining crossing-over in the distal as well as in the proximal segment.

Thus we can see that the genotype controls not only the gross amount of recombination, but also plays a part, together with the cytoplasm, in determining the pattern of response of meiosis to changes of environment. In other respects, the effect of the cytoplasm appears to be confined to a particular region of the chromosome.

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Chromatid Breakage by Irradiation and the Oxygen Effect

SINCE the demonstration by Thoday and Read[1] that the yield of chromosome bridges and fragments produced in X-irradiated *Vicia faba* roots was influenced by the presence of oxygen during irradiation, more detailed investigations on the oxygen response of chromosome and chromatid aberrations have been carried out using *Tradescantia* microspores[2,3]. We have re-investigated the oxygen effect on the chromosomes of *V. faba* root tips, in order to make a detailed analysis of the influence of oxygen on the structure and frequency of the various chromatid aberrations induced by gamma-radiation.

Roots were irradiated with cobalt-60 gamma-rays using doses of 35, 78, 121 and 198r. in de-aerated (nitrogen) water and similarly, with the exception of the highest dose, in aerated water. The lowest two doses were given in 3·5 min. and the highest doses in 3·9 and 4·7 min. respectively. The amount of mitotic delay was known[4] and was insufficient to affect valid comparisons between treatments. The mean frequencies of true chromatid breaks, isochromatid breaks and chromatid interchanges, determined from roots fixed between 3½ and 5 hr. after irradiation, are shown in Fig. 1.

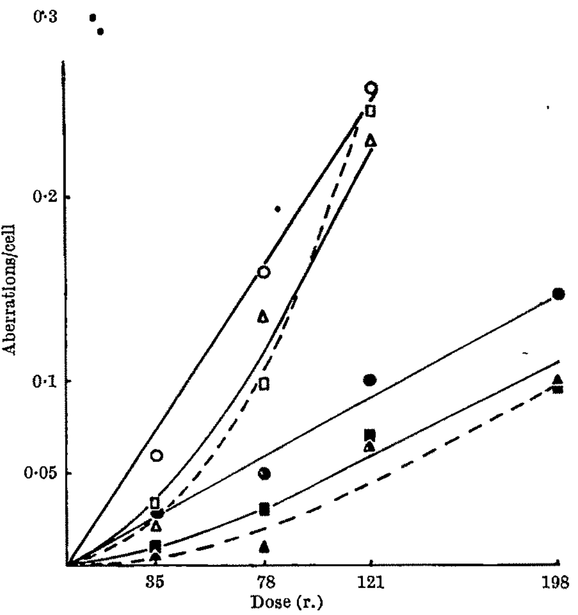

Fig. 1. Chromatid aberration frequency. Open symbols, air. Closed symbols, nitrogen. Mean chromatid break (—○—); isochromatid break (—□—) and interchange (– – – △ – – –) frequency for 400 cells at each point

The slopes of the curves relating frequency of aberration to dose have been determined and are given in Table 1. The results show that the presence of oxygen during irradiation increases the frequency of aberration, but does not change the shapes of the curves, the dose exponents in air and in nitrogen being similar (Table 1). As the shape of the dose-response curve for a given aberration is unaffected by the absence of oxygen, then the ratio of the doses in the absence and presence of air required to produce the same frequency of aberration is simply determined and is found to be the same for the three aberration types, nitrogen : air ~ 2·5 (Table 1). The nitrogen : air dose ratio for achromatic lesions, or gaps, is less than the ratio for the true chromatid aberrations, but there is no statistically significant departure from 2·5. The lower value of 2·1 is perhaps due to the fact that non-staining gaps are a heterogeneous mixture and are difficult to score objectively, especially at the highest doses used.

On the classical model that aberrations are produced by breakage and reunion of chromatids, perhaps the simplest interpretation of the constant dose ratio for the various aberration types, with and without oxygen, is that breakage rather than rejoining is affected. Cytological evidence in favour of this interpretation is obtained through comparing the frequencies of isochromatid and interchange aberrations which are incomplete, that is, those aberrations in which two ends remain unjoined[5]. The proportion of incompleteness found for isochromatid breaks and interchanges respectively was, in air, 30 ± 0·4 per cent and 34 ± 2·6 per cent, and in nitrogen, 35·5 ± 5·7 per cent and 35 ± 5·3 per cent. Thus there was no significant difference in incompleteness in air or nitrogen, a result also found by Conger[6] in X-irradiated *Tradescantia* microspores.

While the results support the view that oxygen increases the initial or primary effect of radiation on the chromosomes, certain details indicate that the primary event may not be the actual breakage of

Table 1. DOSE-RESPONSE EXPONENTS AND OXYGEN FACTOR FOR VARIOUS ABERRATION TYPES

Aberration	Gas	Dose exponent	Dose factor (nitrogen : air)
Chromatid breaks	Air	1·2 ± 0·13	2·51 (1·98–3·17)*
	Nitrogen	1·0 ± 0·12	
Isochromatid breaks	Air	1·5 ± 0·11	2·49 (1·98–3·15)
	Nitrogen	1·4 ± 0·18	
Chromatid interchanges	Air	1·9 ± 0·5	2·58 (1·91–3·50)
	Nitrogen	1·8 ± 0·28	
Gaps	Air	1·1 ± 0·07	2·13 (1·41–2·85)
	Nitrogen	0·7 ± 0·07	

* Fiducial limits at the 5 per cent level

chromatids. The low frequency of true chromatid breaks and the absence of isochromatid aberrations showing no reunion (*Nupd* types[5]) are more in accord with the exchange mechanism for aberration production, as proposed by Revell[7].

Further details and discussion of this work will be published elsewhere.

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Nitrogen Fixation by Gram-Negative Bacteria

Although claims for nitrogen fixation by Gram-negative bacteria other than the *Azotobacter* have been made in the past[1], confirmation of such claims is comparatively recent[2-5]. Nitrogen fixation by particular strains of *Pseudomonas* has been reported by Anderson[2] and by Voets and Debacker[3]. Recently, Jensen[5] isolated from a Danish water-course a nitrogen-fixing organism that appears to be a species of *Achromobacter*. In most of these studies, the investigators were attempting to obtain species such as *Azotobacter* that are known to fix nitrogen; hence the techniques employed would select for this characteristic. Because of the significance of the discovery of these new agents for both theoretical and applied biology we have examined strains of *Pseudomonas* and *Achromobacter* that had been isolated under non-selective conditions.

Using the sensitive tracer nitrogen-15 technique as well as the more conventional Kjeldahl method, we have demonstrated aerobic fixation in six strains of *Pseudomonas* spp. and eight strains of *Achromobacter* spp. All the pseudomonads except *Ps. azotogensis*[3] also fixed anaerobically, but only Jensen's strain of the *Achromobacter* fixed in the absence of oxygen. The fixation process in both genera appears to be controlled by an inducible enzyme system.

The basal medium used throughout contained sucrose 2·0 per cent, disodium hydrogen phosphate 1·25 per cent, potassium dihydrogen phosphate 0·15 per cent, calcium chloride dihydrate 0·01 per cent, magnesium sulphate heptahydrate 0·01 per cent, ferric iron 0·0001 per cent and molybdenum (as molybdate) 0·00001 per cent. Ammonium nitrogen was added as required. Total carbohydrates were determined by the method of Morris[7], aeration values by the method of Cooper *et al.*[8].

Aerobic fixation and growth were studied in 100 ml. cultures in 500 ml. flasks, at 30° C., shaking at 350 r.p.m. on a Brunswick shaker with ¾-in. rotor; these conditions resulted in an aeration value of 0·315 mmoles of oxygen per litre per min. Initial and final aliquots were analysed for nitrogen and total carbohydrates. For the pseudomonads fixation varied from 3·0 to 50·0 μgm./ml. in 4 days, and the efficiencies of fixation from 1·1 to 4·3 μgm. of nitrogen per mgm. of carbohydrate used. Three phases of growth were evident: (*a*) an initial growth; (*b*) a lag phase; (*c*) a second growth phase. The extent of the initial growth depends on the quantity of ammonium nitrogen added to the medium; the lag phase probably reflects the synthesis of the enzyme system responsible for fixation; and the third phase is growth on molecular nitrogen. Analysis of the total increase of nitrogen in 25 ml. shake cultures indicated fixation of from 0·20 to 0·55 mgm. in 14 days. Incorporation of heavy nitrogen was demonstrated using concentrated suspensions of organisms harvested in the second growth phase. Exposure to an atmosphere of 10 per cent nitrogen containing approximately 36 atoms per cent excess nitrogen-15, 20 per cent oxygen and 70 per cent helium was made for 4 hr. at 30° C. in a well-shaken Warburg vessel; analyses showed a final incorporation of greater than 0·1 atoms per cent excess, for all cultures.

Achromobacter spp. showed the same type of growth characteristics; fixation was in the range 3·0–17·0 μgm./ml. in four days. The efficiency was of the order of 1·25 μgm./mgm. of carbohydrate used; nitrogen-15 incorporation ranged from 0·02 to 0·16 atoms per cent excess.

Anaerobically, fixation by the pseudomonads was of the order of 40 μgm./ml.; incorporation of heavy nitrogen was approximately 0·15 atoms per cent excess. The sole strain of *Achromobacter* that fixed anaerobically assimilated 39 μgm. nitrogen/ml., and contained 0·10 atoms per cent excess nitrogen-15.

In common with the nitrogen-fixing systems of other organisms, those in *Pseudomonas* and *Achromobacter* required a greater quantity of iron for the fixation of nitrogen than for growth upon ammonium-nitrogen. When fixing nitrogen, the strains examined possessed a hydrogenase demonstrable by the hydrogen–deuterium exchange reaction but not detectable by the evolution of hydrogen from reduced methyl viologen, or by the uptake of hydrogen on methylene blue.

This demonstration of nitrogen fixation by an apparently inducible enzyme system in a 'random' selection of strains of *Pseudomonas* and *Achromobacter* confirms and extends the investigations from the other laboratories. In the pseudomonads it provides yet another example of the adaptive versatility of the genus. Because of the widespread occurrence of both genera in soil and surface waters, their importance in nitrogen fixation may be considerable.

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Hydrogen Peroxide and Cancer

AFTER consultation with Holman, his experiment[1] was repeated as closely as possible in all details, except the strain of rat used, which was an inbred strain of Wistar origin. Experimental animals and controls carried tumours of the 9th, 10th, 11th and 15th successive transplants into this strain of a Walker carcinoma obtained from the Chester Beatty Research Institute. On the sixth day after inoculation, the drinking water of experimental animals was replaced by 0·45 per cent hydrogen peroxide in tap water. Tumours in experimental animals then ranged from 3·5 to 5·4 cm. longest diameter (mean 4·46 cm.), and in controls from 3·0 to 5·6 cm. (mean 4·48 cm.).

Of 20 experimental animals, 6 died of tumour in 18–36 days after inoculation, in 13 the tumour regressed completely in 17–60 days, and in 1, killed after 66 days, a residual tumour 1·1 cm. long was found. Of 20 controls, 3 died of tumour in 13–26 days, and in 17 the tumour regressed completely in 14–87 days after introduction.

Blood catalase and hæmoglobin values decreased as the tumours grew in size and rose again as they regressed. Blood catalase was approximately proportional to hæmoglobin, as found by Miller[2] for human erythrocyte catalase. The catalase/hæmoglobin ratio, however, tended to be higher for treated rats, with a wider scatter of values than in controls. The difference was not apparent until about a fortnight after the commencement of treatment; mean catalase/hæmoglobin ratios (ml. oxygen liberated per min./gm. hæmoglobin) for rats drinking peroxide for 18 days and more are 1,880 ± 244, and for untreated animals over the same period 1,719 ± 46; the mean difference is 161 ± 74, which has a probability of less than 1 in 20 of arising by chance.

Maximum growth of tumours which afterwards regressed was found at 7–24 days after inoculation, and in 20 of the total 31 regressions at 10–12 days. This appears consistent with an immunological mechanism of regression. Maximum tumour growth was slightly, but not significantly, less for treated animals than controls, and the mean weight of tumour-bearing rats at the time of maximum tumour growth differs significantly, being 193 ± 21 gm. for treated rats and 210 ± 29 gm. for controls—a mean difference of 17 ± 5 gm., with a probability of less than 1 in 100 of arising by chance. These findings are in accord with those of Ghadially and Wiseman[3], who also noted a smaller food intake by rats drinking peroxide. Chorąży *et al.*[4] report decreased liquid intake, which was found also in this experiment. Mean values of 120 observations on each group were 16 ± 4·2 ml. per day for treated rats and 24 ± 4·0 ml. per day for controls—a mean difference of 8 ± 0·3 ml., which is highly significant.

Drinking hydrogen peroxide thus appears to have two effects on the tumour-bearing rat. It slows down growth by reducing food and liquid intake, and it tends to raise the catalase/hæmoglobin ratio in the blood. No effect on survival was found in this experiment.

This work, which was designed as a pilot experiment, was aided by a grant from the University of Bristol Cancer Research Fund. I wish to thank Prof. A. Haddow for the gift of rats bearing the Walker carcinoma, Prof. J. S. Mitchell and Mr. E. A. King for advice and instruction in techniques, Miss E. H. L. Duncan for help with statistical estimations, Dr. C. H. G. Price for his continued interest and advice and Dr. R. A. Holman for discussions of his experiments.

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A White-eyed Mutant Form of the American Cockroach, *Periplaneta americana* (L.)

WHITE-EYED mutants are well known in insects, but the majority of reported cases are confined to the order Diptera. Tate[1], in a paper on a white-eyed mutation in *Calliphora erythrocephala*, gives references to five other dipterans in which it has been known to occur, and more recently Paterson[2] has added another. Comparable mutations in other orders of insects seem to be less frequent, although the related phenomenon of albinism is known in the desert locust[3]. It may be of interest, in view of this, to report the occurrence of a white-eyed mutant form of the American cockroach, *Periplaneta americana* (L.).

This was originally found among a population of these cockroaches in a deep coalmine in Glamorgan and has been kept in pure culture in this Department for more than eleven years. The mutant character behaves as a Mendelian recessive, and observations on the laboratory stock indicate that it is not sex-linked; this point, however, needs further investigation.

During the past eleven years rough sampling of the cockroaches in the pit has been carried out from time to time, and the white-eyed mutants have been found to comprise about 5 per cent of the population. There has been no noticeable tendency towards any change in this proportion throughout the period. It is perhaps surprising that a mutant form should maintain itself at a substantially constant level for such a time, but presumably under mine conditions an unpigmented eye is a neutral character with no selective significance. The conditions of the population when the mutant form was spreading to its present numerical level are, of course, quite unknown. Cockroaches are said to have been present in the pit for a long time, but it is not known when white-eyed forms first appeared, and there is no reliable information about numerical fluctuations of the population as a whole.

In the course of a survey of the fauna of a number of South Wales coalmines, *Periplaneta americana* was found quite commonly, but only in the one pit were white-eyed mutants seen.

G. T. JEFFERSON

Department of Zoology,
University College,
Cathays Park,
Cardiff.
July 25.

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[1] Tate, P., *J. Genet.*, 48, 176 (1947).

[2] Paterson, H. E., *Nature*, 181, 932 (1958).

[3] Hunter-Jones, P., *Nature*, 180, 236 (1957).

FORTHCOMING EVENTS

Tuesday, September 30

Society of Instrument Technology (at Manson House, Portland Place, London, W.1), at 6 p.m.—Prof. J. C. West: "Frequency Response Analysis Using Describing Function Method".

Wednesday, October 1

Institute of Petroleum (at 61 New Cavendish Street, London, W.1), at 5 p.m.—Mr. D. L. Pratt, Mr. G. M. Christie, Mr. E. F. Coxon and Mr. J. R. Lodwick: "Fuels and Lubricants for the Trans-antarctic Expedition"

Society for Analytical Chemistry (at the Royal Institution, 21 Albemarle Street, London, W.1), at 6.30 p.m.—Mr. T. T. Gorsuch: "Application of Radio-Chemical Methods to the Recovery of Trace Elements".

Society of Chemical Industry, Corrosion Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Mr. M. Smialowski (University of Warsaw): "Corrosion Embrittlement; the Effect of Cathodically Evolved Hydrogen on Iron and Nickel".

Royal Institute of Chemistry, London Section (at Eltham College, Grove Park Road, London, S.E.9), at 7.30 p.m.—Mrs. J. Holden, Dr. C. W. Herd, Dr. J. E. Salmon, Mr. P. A. Raine and Mr. W. H. Bennett: "Careers in Chemistry".

Thursday, October 2

Horticultural Education Association and the Association of Applied Biologists (in the Lecture Hall of the British Museum (Natural History), Cromwell Road, South Kensington, London, S.W.7), at 11 a.m.—Joint Symposium on "The Relationships of Root to Shoot Growth in Plants".

Linnean Society of London (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Mr. F. N. Hepper: "Botanical Expedition to Adamawa, British Cameroons"; Dr. H. B. D. Kettlewell: "Darwin and the Insects of Brazil" (a sound and colour film).

Society of Chemical Industry, Microbiology Group (at 14 Belgrave Square, London, S.W.1), at 6.15 p.m.—Meeting on "Physical Methods in Microbiology".

Polarographic Society (at "The Duke of York", 8 Dering Street, London, W.1), at 7 p.m.—Informal Discussion Meeting on "Polarographic Problems in the Nylon Industry" introduced by Mr. R. D. Middleton.

Friday, October 3

Society of Chemical Industry, Fine Chemicals Group (at 14 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. B. A. Hems: "Cortisone from Hecogenin".

Saturday, October 4

Association of Clinical Biochemists and the Association of Clinical Pathologists (at the Royal College of Surgeons, Lincoln's Inn Fields, London, W.C.2) at 9.30 a.m. and 2 p.m.—Scientific Meeting, including a Symposium on "Quantitative Paper Chromatography".

Nutrition Society (at the London Hospital Medical College, Turner Street, London, E.1), at 10.20 a.m.—Symposium on "Nutrition and Teeth".

APPOINTMENTS VACANT

Applications are invited for the following appointments on or before the dates mentioned:

Statistical Engineer (mathematician or statistician with a university degree in mathematics or statistics, and preferably a knowledge of meteorology) in the System Operation Branch, Central Electricity Generating Board Headquarters, London, S.E.1, for duties which include investigations requiring the application of advanced statistical and probability methods to engineering problems associated with the operation of a large interconnected electricity supply system, with particular reference to short-term load estimation and to the study of the effect of weather on system load—Personnel Officer, Central Electricity Generating Board, 24/30 Holborn, London, E.C.1, marking envelope "Confidential" and quoting Ref. No. N/268 (October 3).

Lecturer in Education—The Principal, Borough Road College, Isleworth, Middlesex (October 6).

Senior Lecturer or Lecturer (with a good honours degree and teaching experience) in Geography at Fourah Bay College (University of Durham), Sierra Leone—The Secretary, Council for Overseas Colleges, 12 Lincoln's Inn Fields, London, W.C.2 (October 6).

Research Student (with a good honours degree in zoology) in the Department of Zoology, for work in river ecology—The Secretary, The University, Exeter (October 10).

Assistant Lecturer (with special qualifications or interests in radio astronomy) in Physics—The Registrar, The University, Manchester 13 (October 11).

Lecturer or Demonstrator (with a medical or dental qualification or an honours degree in physiology or biochemistry) in Physiology—The Registrar, King's College (University of Durham), Newcastle-upon-Tyne (October 11).

Research Assistant (graduate) in the Department of Agriculture to carry out investigations into the efficiency of farm buildings by the application of work study methods—The Secretary and Registrar, University College of North Wales, Bangor, North Wales (October 13).

Lecturer (preferably with interests and experience in protein and/or enzyme biochemistry) in the Department of Applied Biochemistry—The Deputy Registrar, The University, Birmingham 15 (October 15).

Research Physicist (preferably with experience in the use of ultra-high vacuum systems or in the chemical physics of surfaces) in the Department of Physics, for work which will involve electrical measurements applied to the study of surface contamination processes on semi-conductors—The Professor of Physics, University of Reading, Physics Research Laboratories, Upper Redlands Road, Reading, Berks (October 24).

Senior Lecturer in the Department of Mathematics, University of the Witwatersrand, Johannesburg, South Africa—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (South Africa, October 25).

Chair of Medicine tenable at St. George's Hospital Medical School—The Academic Registrar, University of London, Senate House, London, W.C.1 (October 28).

Scientific Officer (with a good honours degree and preferably two or three years postgraduate experience) in the Entomology Department to work on some problems concerning the biology of forest soils—The Secretary, Rothamsted Experimental Station, Harpenden, Herts, quoting Ref. 1051/12 (October 30).

National Coal Board Postdoctoral Fellow in Physical Chemistry to undertake research work connected with the study of solids by a number of techniques such as mass spectroscopy—The Registrar, The University, Birmingham 15 (October 31).

Principal (with high academic qualifications and appropriate educational and administrative experience) of the Northern Polytechnic—The Clerk, Northern Polytechnic, Holloway, London, N.7 (October 31).

Regius Chair of Botany in the University of Aberdeen—The Private Secretary, Secretary of State for Scotland, St. Andrew's House, Edinburgh 1 (November 10).

Research Fellow or Senior Research Fellow in the Colonial Products Council Natural Products Research Unit, Chemistry Department, University College of the West Indies—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (November 10).

Assistant (preferably with a science degree and a knowledge of languages) for Information Service for duties which include assisting with public relations activities, sub-editing, and internal information work—The Secretary, National Institute for Research in Dairying (University of Reading), Shinfield, Reading, Berks, quoting Ref. 58/25.

Chair of Metallurgy—The Secretary, The Royal College of Science and Technology, Glasgow.

Entomologist (with a good honours degree in natural science and some research experience in entomology) in the Agricultural Department, Trinidad, to carry out research on biology and control of insect pests of coconuts and to co-operate in assessing their importance as vectors of red ring disease—The Director of Recruitment, Colonial Office, London, S.W.1, quoting Ref. BCD.63/38/01.

Laboratory Technicians to work in the Physics Research Laboratories—The Bursar, The University, Reading.

Postgraduate Student (preferably with experience in systematic bacteriology, serology, or nutritional studies of bacteria) for research in the Bacteriology Department—The Secretary, Queen Elizabeth College (University of London), Campden Hill Road, London, W.8.

Research Physicist or Engineer (preferably with a knowledge and aptitude for hydrodynamics) to undertake model research on fluid flow—The Meteorology Department, Imperial College of Science and Technology, London, S.W.7.

Senior Lecturer in Applied Physics; a Lecturer in Physics; and an Assistant (Grade B) for Mathematics—The Clerk to the Governors, Mid-Essex Technical College, Market Road, Chelmsford, Essex.

Senior Plant Breeder (with a good honours degree in botany and postgraduate experience in the technique of plant improvement) at the West African Cocoa Research Institute, to carry out research on plant breeding problems relating to cocoa and to plan and take charge of the work of the Plant Breeding Section of the Institute, serving initially at Tafo, Ghana—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.197/200/024.

Senior Scientific and Scientific Officers (with a first- or second-class honours degree in physics, mathematics or engineering or equivalent) at the Government Communications Headquarters, Cheltenham, for telecommunications and electronic research in the following fields: V.H.F. receiver design and microwave techniques, propagation trials; applications of semi-conducting devices; high speed electronic switching; data storage and handling; computer programming, and operational research—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A147/8A.

REPORTS and other PUBLICATIONS

(not included in the monthly Books Supplement)

Great Britain and Ireland

Monsanto Mail, No. 1. Pp. 24. (London: Monsanto Chemicals, Ltd., 1958.) [227

Ministry of Labour and National Service. Safety, Health and Welfare Booklets, New Series. No. 1: Lifting and Carrying. Pp. 12. 1*s.* net. No. 3: Safety Devices for Hand and Foot Operated Presses. Pp. 32. 2*s.* 6*d.* net. (London: H.M. Stationery Office, 1958.) [257

Forestry Commission. Forest Record No. 36: Provisional Yield Tables for Oak and Beech in Great Britain. By W. T. Waters and J. M. Christie. Pp. 32. (London: H.M. Stationery Office, 1958.) 2*s.* 6*d.* net. [257

Department of Scientific and Industrial Research. Radio Research 1957: The Report of the Radio Research Board and the Report of the Director of Radio Research. Pp. iv+43+4 plates. (London: H.M. Stationery Office, 1958.) 3*s.* 6*d.* net. [257

In commemoration of Professor Frederick Soddy, M.A., Ll.D., F.R.S., Nobel Laureate, formerly President of the New Europe Group, who died 22nd September, 1956. Pp. 24. (London: New Europe Group, 96 Charlotte Street, W.1, 1958.) 5*s*. [257

Education in 1957: Being the Report of the Ministry of Education and the Statistics of Public Education for England and Wales. Pp. v+198. (Cmnd. 454.) (London: H.M. Stationery Office, 1958.) 9*s*. net. [257

The Annual Report of the East Africa High Commission for 1957. Pp. x+85. (London: H.M. Stationery Office, 1958.) 7*s*. 6*d*. net. [257

The A.B.C. of Atomic Energy. By Sir Christopher Hinton, F.R.S. Edited by John Dixon and J. P. Farthing. Pp. 40. (London: British Broadcasting Corporation, 1958.) 1*s*. 3*d*. [257

Redundancy: a Survey of Problems and Practices. Pp. vi+56. (London: The Acton Society Trust, 1958.) 5*s*. [257

Bulletin of the British Museum (Natural History). Entomology. Vol. 7, No. 1: The Mealy-Bugs (Pseudococcidae: Homoptera) described by W. J. Hall, F. Laing and A. H. Strickland from the Ethiopian Region. By D. J. Williams. Pp. 1–37. (London: British Museum (Natural History), 1958.) 10*s*. [257

Ministry of Agriculture, Fisheries and Food; Department of Agriculture for Scotland; Ministry of Agriculture, Northern Ireland. Output and Utilization of Farm Produce in the United Kingdom, 1946–47 to 1955–56. Pp. v+51 (26 tables). (London: H.M. Stationery Office, 1958.) 4*s*. 6*d*. net. [257

Agreement between the Government of the United Kingdom of Great Britain and Northern Ireland and the Government of the United States of America for Co-operation on the Uses of Atomic Energy for Mutual Defence Purposes, Washington, July 3, 1958. Pp. 8. (Cmnd. 470.) (London: H.M. Stationery Office, 1958.) 6*d*. net. [257

Atom 1958. Pp. 24. (London: H.M. Stationery Office, 1958. Published for the United Kingdom Atomic Energy Authority.) [307

United Kingdom Atomic Energy Authority. Fourth Annual Report for the period 1st April, 1957–31st March, 1958. Pp. vi+68. (London: H.M. Stationery Office, 1958.) 4*s*. 6*d*. net. [307

Department of Scientific and Industrial Research. Road Research, 1957: The Report of the Road Research Board with the Report of the Director of Road Research. Pp. iv+93+8 plates. (London: H.M. Stationery Office, 1958.) 5*s*. 6*d*. net. [307

Yours Faithfully. Pp. 12. (London: B. and K. Laboratories, Ltd., 1958.) [307

Alfa-Laval—De Laval: The Idea That Grew Into a World Industry. (75th Anniversary Souvenir Brochure.) Pp. 35. (Brentford, Mddx.: Alfa-Laval Company, Ltd., 1958.) [307

Other Countries

United States Department of Commerce: National Bureau of Standards. Circular 594: Preparation, Maintenance, and Application of Standards of Radioactivity. By W. B. Mann and H. H. Seliger. Pp. iv+47. (Washington, D.C.: Government Printing Office, 1958.) 35 cents. [227

United States Department of Commerce: Weather Bureau. Technical Paper No. 29: Rainfall Intensity-Frequency Regime. Part 2: Southeastern United States. Pp. v+51. (Washington, D.C.: Government Printing Office, 1958.) [227

Smithsonian Miscellaneous Collections. Vol. 135, No. 8: Miscellaneous Notes on Fossil Birds. By Alexander Wetmore. Pp. i+11+5 plates. (Publication 4335.) (Washington, D.C.: Smithsonian Institution, 1958.) [227

Carnegie Institution of Washington. Annual Report of the Director of the Department of Terrestrial Magnetism, 1956–1957. Pp. ii+83–147+5 plates. (Reprinted from *Carnegie Institution of Washington Year Book*, 56, for the year July 1, 1956–June 30, 1957.) (Washington, D.C.: Carnegie Institution of Washington, 1957.) [227

Canada: Department of Mines and Technical Surveys. Geological Survey of Canada. Memoir 284: Yukon Territory: Selected Field Reports of the Geological Survey of Canada, 1898–1933. Compiled and Annotated by H. S. Bostock. Pp. xiii+650. (Ottawa: Queen's Printer, 1957.) 3 dollars. [227

Guide Book to Research Data for Arid Zone Development. Edited by B. T. Dickson. (Arid Zone Research Series, Vol. 9.) Pp. 191+17 plates. (Paris: Unesco; London: H.M. Stationery Office, 1957.) 1,250 French francs; 25*s*.; 5 dollars. [227

Proceedings of the United States National Museum. Vol. 108, No. 3393: Type Specimens of Lice (Order Anoplura) in the United States National Museum. By Phyllis T. Johnson. Pp. 39–50. Vol. 108, No. 3394: A New North American Bird-Flea. By F. G. A. M. Smit. Pp. 51–58. Vol. 108, No. 3396: A Redefinition of the Butterfly Genera *Tatochila*, *Phulia*, *Piercolias*, and *Baltia*, with descriptions of Related Genera and Subgenera. By William D. Field. Pp. 103–132. Vol. 108, No. 3397: The Systematic Position of the Bird Genus *Apalopteron*. By H. G. Deignan. Pp. 133–136. (Washington, D.C.: Government Printing Office, 1958.) [227

Economic Development in the Middle East 1956–1957: Supplement to World Economic Survey, 1957. Pp. xi+163. (New York: United Nations; London: H.M. Stationery Office, 1958.) 1.75 dollars; 12*s*. 6*d*.; 7.50 Swiss francs. [227

National Science Foundation, Washington, D.C. A Selected Bibliography of Research and Development and Its Impact on the Economy. Pp. v+21. (NSF–58–18.) (Washington, D.C.: Office of Special Studies, National Science Foundation, 1958.) [227

Annals of the New York Academy of Sciences. Vol. 70, Article 4: Nuclear Magnetic Resonance. By H. S. Gutowsky and 17 other authors. Pp. ii+765–928. (New York: New York Academy of Sciences, 1958.) [227

Electric Technology, U.S.S.R., Vol. 1, May 1958: Selected papers from *Elektrichestvo*, Nos. 1–4, 1957. Four volumes per annum. Approximately 700 pages per annum. Annual subscription rate £20 (56 dollars). Single volumes £6. (17 dollars). (London and New York: Pergamon Press, 1958.) [227

United States Department of the Interior: Geological Survey. Bulletin 1019–L: Selected Annotated Bibliography of Asbestos Resources in the United States and Canada. By Ruth Butler, Mary L. Conant and Helen F. Weissenborn. Pp. iii+817–865. 25 cents. Bulletin 1046–G: Uranium in Carbonaceous Rocks in the Townsend and Helena Valleys, Montana. By George E. Becraft. Pp. iii+149–164+plate 3. Bulletin 1070–A: A Reconnaissance of the Idaho Batholith and Comparison with the Southern California Batholith. By Esper S. Larsen, Jr., and Robert George Schmidt. Pp. iv+33+plate 1. 50 cents. Water-Supply Paper 1227-C: Floods of 1950–51 in the Catskill Mountain Region, New York. Prepared under the direction of J. V. B. Wells. Pp. vii+201–277+plate 3. Water-Supply Paper 1291: Quality of Surface Waters of the United States, 1953, Parts 5–6. Prepared under the direction of S. K. Love. Pp. ix+472. 1.25 dollars. Water-Supply Paper 1379: Ground-Water Resources of the San Luis Valley, Colorado. By William J. Powell. With a section on An Inflow-Outflow Study of the Area by Philip B. Mutz. Pp. vii+284+plates 1–16. Professional Paper 287: Geology and Magnetite Deposits of Dover District, Morris County, New Jersey. By Paul K. Sims. With a description of the Geologic Section at Hibernia Mine by A. F. Buddington. Pp. vii+162+22 plates. (Washington, D.C.: Government Printing Office, 1958.) [227

Chicago Natural History Museum. Fieldiana: Zoology. Vol. 36, No. 4: Catalogue of Type Specimens of Reptiles and Amphibians in Chicago Natural History Museum. By Hymen Marx. Pp. ii+409–496. (Chicago: Chicago Natural History Museum, 1958) 1.25 dollars. [227

The Story of Transportation as Told by Historic Originals and Scale Models in the Smithsonian Institution. By E. John Long. Pp. 36+25 color stamps. (Smithsonian publication No. 4312.) (Washington, D.C.: Smithsonian Institution, 1958.) [227

Institut Royal Meteorologique de Belgique. Publications, Serie A, No. 5: Nouveau Levé Magnétique de la Belgique. Première partie: Lignes des Isodifférences de H et Z au 1er Janvier 1955. Lignes des Isodifférences de D au 1er Janvier 1957. Par E. Lahaye, L. Koenigsfeld, A. De Vuyst et E. Hoge. Pp. 95 (22 planches). Publications, Serie B, No. 23: Connexions Thermiques entre Saisons Consécutives a Bruxelles-Uccle. Par R. Sneyers. Pp. 23. Publications, Serie B, No. 24: Le Temps en 1957. Par R. Sneyers. Pp. 48. Contributions, No. 39: Nitrogen Oxides and the Airglow. By Dr. Marcel Nicolet. Pp. 17. Contributions, No. 40: l'Année Géophysique Internationale 1957–1958—Participation de la Belgique. Par Dr. E. Lahaye. Pp. 11. (Uccle-Bruxelles: Institut Royal Meteorologique de Belgique, 1957 et 1958.) [227

United States Department of Agriculture. Index-Catalogue of Medical and Veterinary Zoology. Supplement 8: Authors A to Z. By Mildred A. Doss, Judith M. Humphrey and Dorothy B. Segal. Pp. ii+337. (Washington, D.C.: Government Printing Office, 1958.) [257

Proceedings of the American Academy of Arts and Sciences. Vol. 85, No. 4: Records of the Academy, 1957–1958. Pp. 247–362. (Boston, Mass.: American Academy of Arts and Sciences, 1958.) [257

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Bulletin of the Academy of Sciences of the U.S.S.R.—Geophysics Series, No. 1, 1957. English edition. Issued monthly. Pp. 148. Annual subscription: 25 dollars; 190*s*. (New York and London: Pergamon Press, 1957.) [257

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World Health Organization. Technical Report Series. No. 145: Expert Committee on Poliomyelitis—Second Report. Pp. 83. (Geneva: World Health Organization; London: H.M. Stationery Office, 1958.) 2 Swiss francs; 3*s*. 6*d*.; 0.60 dollars. [257

Tokyo Astronomical Observatory. Tokyo Astronomical Bulletin, Second Series. No. 101 (December 5, 1957): Meridian Observation of Right Ascension of Equatorial Stars made with Repsold Transit Instrument. Preliminary Results No. 12 (January–June 1956). By Konosuke Tuzi. Pp. 1061–1102. No. 102 (January 20, 1958): Photoelectric Observations of ε Aurigae. By M. Huruhata and M. Kitamura. Pp. 1103–1105. (Tokyo: Tokyo Astronomical Observatory, 1957 and 1958.) [257

B.A.N.Z. Antarctic Research Expedition, 1929–1931. Reports, Series B (Zoology and Botany). Vol. 6, Part 7: Mollusca of Kerguelen and Macquarie Islands. By A. W. B. Powell. Pp. 107–150+2 plates. 12*s*. Vol. 6, Part 8: Medusae. By P. L. Kramp. Pp. 151–164. 6*s*. Vol. 6, Part 9: Mollusca from the Victoria-Ross Quadrants of Antarctica. By A. W. B. Powell. Pp. 165–214+3 plates. 15*s*. (Adelaide: B.A.N.Z.A.R. Expedition Committee, 1957 and 1958. Issued through the Barr Smith Library, University of Adelaide.) [257

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LECTURES AND COURSES

PORTSMOUTH COLLEGE OF TECHNOLOGY

DEPARTMENT OF CHEMISTRY AND BIOLOGY

SANDWICH COURSE IN CHEMISTRY

For the third consecutive year the Sandwich Course in Chemistry will be held, commencing in September, 1958. The Course prepares for the examinations leading to the Graduateship of the Royal Institute of Chemistry. The Course (Works-based and College-based) is of four years' duration and involves six months' study at College each year. The normal requirements for admission will be passes at "A" level (G.C.E.) in chemistry together with physics and/or mathematics, or a national certificate in chemistry. Some vacancies still remain. Inquiries from industrial firms, government departments and individual students welcomed.

Particulars from the Registrar, College of Technology, Park Road, Portsmouth.

UNIVERSITY OF LONDON: A COURSE OF two lectures entitled (i) "The Postulate of Invariance in Evolution"; (ii) "The Cortical Correlate of Perceptual Organization" will be delivered by Professor W. Köhler (Princeton) at 5.30 p.m. on October 7 and 9 at University College (Physiology Lecture Theatre), Gower Street, W.C.1. Admission free, without ticket.—James Henderson, Academic Registrar.

OFFICIAL APPOINTMENTS

FEDERATION OF NIGERIA

DEPARTMENT OF AGRICULTURAL RESEARCH

Agricultural specialist staff are required as follows: Plant Breeders. To undertake research on rice and legume crops. Plant Pathologists. To study crop plant diseases and devise means for their eradication or control. Agronomists. To assess problems of field husbandry and to assist in the economic application of the results of research on coffee, kola, fruit, rice, and legume crops. Horticulturist or Economic Botanist. To plan the introduction and exploitation of plants of economic importance to Nigeria. Microbiologist and Chemist. To carry out team research into improvements of soils and crops under high rainfall conditions. Analyst. To carry out analysis and testing of soil and plant materials in connection with the research programme of the soils and crops nutrition team and to supervise the routine work in the Chemistry Laboratory. Animal Geneticist. To advise on the animal breeding policies of the Regional Departments of Agriculture. Candidates must, in all cases, have a good honours degree in the appropriate subject with suitable postgraduate experience or training. Appointments on contract/gratuity terms with emoluments in scale £966 to £1,824 per annum. Gratuity of £25 to £37 10s. for each completed period of three months' satisfactory service. Outfit allowance £60. Free return passages for officer, wife and children up to equivalent of four adult passages in all. Furnished quarters, usually available, at moderate rental.

Apply, giving brief particulars to, Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/14/02.

UNIVERSITY OF HONG KONG

SENIOR RESEARCH OFFICER OR RESEARCH OFFICER IN THE FISHERIES RESEARCH UNIT

Applications are invited for this post within the Department of Zoology. Annual salary (superannuable) is: Senior Research Officer: £2,000 by £75 to £2,300 or Research Officer: £1,575 by £50 to £2,175. There is also an annual expatriation allowance of £250 or £225, depending on the scale to which the successful applicant is appointed. The equivalent of income tax in the Colony is comparatively low. First-class sea passages are provided for expatriate staff and their families on first appointment and leaves. Furnished accommodation is provided for expatriate staff at reasonable rents. Applicants should be men who are qualified zoologists with experience of fisheries research. The successful applicant will be required to take up his duties on January 1, 1959.

Further particulars and information as to the method of application may be obtained from the Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1. The closing date for the receipt of applications, in Hong Kong and London, is October 30, 1958.

CHELSEA COLLEGE OF SCIENCE AND TECHNOLOGY

MANRESA ROAD, S.W.3

DEPARTMENT OF CHEMISTRY

The Governors invite applications for the following posts: (a) Senior Lecturer in Analytical Chemistry with special experience of some aspect of this subject, e.g., the Analysis of Food and Drugs, or Micro-analytical Methods. Industrial or research experience is essential. (b) Lecturer with special interests in Physical Organic Chemistry and with postgraduate experience in this field. (c) Lecturer with special knowledge of Theoretical Inorganic Chemistry and with postgraduate experience in this field. (d) Lecturer or Assistant Lecturer in Organic Chemistry with postgraduate experience. For appointments (b), (c), (d) (except that of Assistant Lecturer) some previous teaching experience is regarded as essential. The appropriate salary scales for men are as follows: (i) Senior Lecturer, £1,350 by £50 to £1,550; (ii) Lecturer, £1,200 by £30 to £1,350; (iii) Assistant, Grade B, £650 by £25 to £1,025, plus additions for training (£25 to £75); graduate status (£75); good honours degree (£50), and London allowance of £36 or £48 according to age. The salary scales and additions for women are slightly less than those for men but are subject to equal pay increments leading to equalization as from April 1, 1961.

Particulars and forms of application from the Clerk to the Governors, to whom applications should be submitted by October 13, 1958.

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to work on the labelling of complex compounds with radioactive isotopes.

Applicants should possess at least a first- or second-class honours degree and have a special aptitude for exacting preparative chemistry.

Appointments will be made as Scientific Officers (£645 to £1,120) or Senior Scientific Officers (£1,215 to £1,425) with good prospects of promotion to higher posts, under the standard conditions of service in the United Kingdom Atomic Energy Authority.

Apply to the Personnel Officer (1225Y/34), The Radiochemical Centre, Amersham, Buckinghamshire.

UNIVERSITY OF MANCHESTER

Applications are invited for the post of Assistant Lecturer in Physics with special qualifications or interests in radio astronomy. Salary scale £700 to £850 per annum with membership of the F.S.S.U. and Children's Allowance Scheme.

Applications should be sent not later than October 11, 1958, to the Registrar, the University, Manchester, 13, from whom further particulars and forms of application may be obtained.

WELSH COLLEGE OF ADVANCED TECHNOLOGY

REGIONAL TECHNICAL INFORMATION OFFICER

Applications are invited for the post of Regional Technical Information Officer, to be based on the College. Applicants should be qualified in pure or applied science with a broad background of knowledge and experience. In the first instance the post is temporary for eighteen months. The salary offered will be between £1,350 to £1,550, depending upon qualifications and experience.

Further particulars may be obtained from the Principal, at the College, Cathays Park, Cardiff.

ROBERT E. PRESSWOOD,
Clerk to the Governors.

City Hall, Cardiff.

APPLICATIONS ARE INVITED FOR THE post of Physiologist (or Pharmacologist) with the Medical Research Council in the Department of the Regius Professor of Medicine, Radcliffe Infirmary, Oxford. The applicant should have a Ph.D. or equivalent experience of research. Research is contemplated into various problems connected with neurohumoral physiology. Experience in pharmacological assay, experimental physiology or electro-physiology is desirable. Salary approximately £1,150. The post comes under the F.S.S.U. for superannuation.—Applications to be sent to the Regius Professor of Medicine at the above address.

NIGERIAN COLLEGE OF ART SCIENCE AND TECHNOLOGY

Principal: C. A. Hart, C.M.G., T.D., D.S Ph.D., M.I.C.E., M.I.Mech.E., F.R.I.C A.M.I.Struct.E.

Applications are invited for the posts (a) Senior Lecturer in Applied Mathematics (b) 2 Lecturers in Mathematics. Qualificatio Good honours degree and teaching experie Salary scale (Pensionable): (a) Grade II, £1,41 £1,740 per annum or Grade I, £1,800 to £1 per annum; (b) £804 to £1,690 per annum cluding inducement addition for overseas ca dates. Entry point according to experie Appointment on contract at 10 per cent hi basic salary plus gratuity £100 to £150 per an can be made if preferred. Partly furnished h at moderate rent; 7 days' leave, normally ta annually, for each month of resident ser Free first-class passages. Children's U.K. m tenance grant up to £150 annually and pass assistance. Free medical attention.

Applications (six copies), giving age, quali tions, experience and names of three refe should be sent to The Council for Ove Colleges, 12 Lincoln's Inn Fields, London, W. Closing date October 6, 1958.

Middlesex County Council Educati Committee

BRUNEL COLLEGE OF TECHNOLOGY

WOODLANDS AVENUE, ACTON, W.3

There are the following three vacancies lecturers at the College, each post being with the Burnham Scale range £1,236 to £1,398 annum.

1. LECTURER IN SPECTROSCOPY to tea the subject in courses for the Diploma in Tec nology. Degree and professional qualificatio necessary, and the person appointed may be quired to give assistance with the teaching Physical Chemistry. Ability to advise resea students in the use of spectroscopic techniq desirable.

2. LECTURERS IN ELECTRONICS (2 po in the Department of Electronics to teach subject in its physical and applied aspects. T Department is responsible for the teaching Electronics throughout the College. A go understanding of the fundamentals of electroni industrial or research experience is necessary a university or technical college experience desira but not essential.

The College, which occupies very pleas modern buildings, is new and developing rapid it offers courses for the Diploma in Technolo University of London degrees and other qu fications. There are many interesting educatio problems associated with its new courses. C contact is maintained with industry and major research organizations, and every encour ment is given to staff to undertake research.

Those interested in the above posts should at once to the Principal.

C. E. GURR, M.Sc., Ph.D
Clerk to the Governing Bod

UNIVERSITY OF READING

Research Assistant wanted for work on physiology of flowering in carnations. The appo ment would be, in the first instance, for one only. Candidates should have a good first de in botany or horticulture; research experience a higher degree an advantage. Salary betw £450 and £600 per annum according to age experience.

Applications to Professor O. V. S. Hea Department of Horticulture, The Univers Reading.

SENIOR SCIENTIFIC AND SCIENTI Officers, required at Government Communicati Headquarters, Cheltenham, for telecommunicati and electronic research in following fields: V.F receiver design and microwave techniques; pro gation trials; applications of semi-conducting vices; high speed electronic switching; data s age and handling; computer programming, operational research. Candidates must norm be natural born British subjects of natural British parents. First- or second-class hon degree in physics, mathematics or engineering equivalent, at least three years' postgraduate perience for Senior Scientific Officer. Salaries men (provincial rates) Senior Scientific Offic £1,130 to £1,330; Scientific Officer, £595 to £1,0 (according to age and qualifications). Appoi ments unestablished but opportunities to comp for established posts.—Forms from Ministry Labour and National Service, Technical and Scie tific Register (K), 26 King Street, London, S.W quoting A147/8A.